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Commander's Decision Aid for Predictive Battlespace Awareness (CDA4PBA)

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Air Force Research Laboratory
Human Effectiveness Directorate
Warfighter Interface Division
Cognitive Systems Branch
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The objective of Information Warfighter Effectiveness (IWE), Commander's Decision Aid for Predicted Battlespace Awareness (CDA4PBA), was to develop and demonstrate human-centered decision-making technologies to improve processes, performance, tools, and training to support a commanders' predictive battle-space awareness ability. The program provided an understanding of the decisions and other cognitive work associated with Predicted Battlespace Awareness (PBA) for Joint Force and Air Force Commanders, their staff and intelligence support functions. CDA4PBA supports a commander's PBA by proposing algorithms and high-level concept visualizations supporting these algorithms. This allows the commander to identify and rehearse actions to counter the enemy's actions before the enemy acts. This program addressed these advanced visualizations and work-centered decision aides.

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PART I: COMMANDER'S DECISION AID FOR PREDICTIVE BATTLESPACE AWARENESS (CDA4PBA) REPORT

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Acknowledgements

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- The 614th Space Intelligence Squadron (SIS)
- The 609th AIS
- The 609th Combat Plans Squadron (CPS)
- The 32nd AIS
- The AF/XOIRB at the Pentagon
- National Air & Space Intelligence Center
- The Air and Space Operations Center (AOC) Strategy Requirements Working Group
- The Joint Forces Air Component Commander (JFACC) Mentors

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1 Introduction

The objective of Information Warfighter Effectiveness (IWE) Delivery Order 0006, Commander's Decision Aid for Predicted Battlespace Awareness (CDA4PBA), was to develop and demonstrate human-centered decision-making technologies to improve processes, performance, tools, and training to support a commanders' predictive battle-space awareness ability.

The program provided an understanding of the decisions and other cognitive work associated with Predicted Battlespace Awareness (PBA) for Joint Force and Air Force Commanders, their staff and intelligence support functions. CDA4PBA supports a commander's PBA by proposing algorithms and high-level concept visualizations supporting these algorithms. This allows the commander to identify and rehearse actions to counter the enemy's actions before the enemy acts. This program addressed these advanced visualizations and work-centered decision aides.

2 Approach

The project team consisted of SRA International, Inc. (SRA) as the prime contractor, Charles River Analytics, DMM Ventures, and ManTech Aegis as subcontractors. As prime contractor, SRA International provided overall project direction, participated in subcontractor activities, and managed the project. Charles River Analytics brought experience through a subject-matter expert (SME) who participated as a United States Air Force (USAF) Scientific Advisory Board member on the panel for 'Predictive Battlespace Awareness to Improve Military Effectiveness' as well as knowledge in expert systems and human factors engineering. DMM Ventures brought experience through an SME who served as a USAF Colonel and helped advance strategy planning and developed effects-based operations doctrine. ManTech Aegis brought a unique cognitive task analysis methodology for capturing user goals, processes, and information requirements in the PBA domain.

The project plan included identifying PBA requirements for USAF users by completing a literature review, data collections, and a cognitive task analysis (CTA). Given that PBA was a relatively new concept, substantiated by lack of doctrinal definition, the first step was to find out exactly what PBA meant to the users within the USAF. PBA doctrine, instructions, and pamphlets provided limited insight, in that they were still being formulated during the project. The immature and unofficial PBA lexicon led to differences in how individuals and organizations interpreted the purpose, approach, and expectations of PBA. Two typical questions posed early in the knowledge elicitation process were "What is PBA?" and "How do you use PBA?"

Three USAF sites representing a cross-section of "users of PBA" were selected for initial knowledge elicitations. Existing operational conflicts posed a risk that knowledge elicitations would be delayed or unavailable. The information from these meetings was necessary to build a network of additional potential site visits. Following the CTA, the project continued with defining user requirements, from which visualization concepts would be derived and developed.

2.1 Refine Project Plan

The project was funded to put the emphasis on data collections and user requirements. However, the first planned data collection was delayed several months due to scheduling conflicts at user sites brought on by the operational realities of on-going real-world conflicts. The last originally planned data collection occurred shortly after the time at which user requirements were to be developed. The CTA process, though, required several months development time for the initial report, followed by additional data collections to further refine the findings prior to final analysis. Therefore, initial user requirements were developed in parallel with the CTA report, as results became available. Furthermore, initial knowledge elicitations indicated PBA was pervasive and influenced many elements within the Air & Space Operations Center (AOC), so developing user requirements would be time-consuming. The team was looking for a focus area to help drive PBA and give the project momentum to move forward in lieu of immediately available user requirements.

2.2 Further Refine Project Plan

While the CTA was moving at a slower pace than expected, the pressure to develop a product led to reprioritization and development in a parallel path with the CTA. The project team had significant experience with predictive algorithm development and those capabilities were leveraged to complement both requirement and visualization development. Two predictive algorithm approaches were pursued: one very basic that involved integrating existing capabilities to create a quick-turn platform for demonstrating decision-aiding and visualization concepts via existing applications; and another higher risk, higher return approach at a more conceptual level.

These approaches were prompted by the team's desire to develop a CDA4PBA demonstration capability beyond storyboard concepts, and to provide a robust demonstration for a meeting by the PBA requirements group at the Pentagon (initially required at the three-letter level, XOI). The goal was to spiral quickly through these capabilities. However, funding reductions occurred shortly after spiral one was kicked off and subsequent spirals could not be developed.

3 Project Activities

The project followed a human-centered, systems engineering process. The project began with a literature review and preparations for data collections or knowledge elicitation sessions at user sites, to define PBA and its use in the USAF AOC. Findings from the knowledge elicitations were used to generate user-focused system requirements. These requirements were used to derive and design PBA visualization prototype concepts. While the project did not follow this plan in the exact serial sequence, for reasons stated earlier, the basic knowledge capture, requirements definition, and concept development occurred, but often in parallel and with a priori knowledge, as necessary.

3.1 Understanding PBA

In order to develop visualizations, the PBA environment had to first be understood. Several techniques were used to perform analysis of the information collected, to include: work flow, performance, process, control and functional requirements, collaboration technologies, information flow, decisions, and strategy analysis (in the context of work performed by JFACC, as it applies to the integration of PBA). Special focus was on cognitive requirements, perception requirements, comprehension and projection (and their impact on information displays, with respect to ordering), retrieval, and other aspects that may impact cognitive capabilities.

3.1.1 Document Review

A scientific and technical literature review was conducted to determine the current state of the art in the PBA domain. A repository was established so all team members could review, access, and build upon available references. References used in developing the WDAR are included in Section 8.

3.1.2 Knowledge Elicitations

The objective of the knowledge elicitations (KE) was to gather, through a combination of methods, a complementary set of information about the PBA decision-making problem space. Typically, the work domain analysis is performed based on a variety of KE activities. This involves interactions with expert practitioners in the domain and includes

face-to-face interviews with the experts, watching the experts work in the domain, verbal protocol techniques, and other Cognitive Task Analysis (CTA) and Cognitive Work Analysis (CWA) methods. This was an iterative, progressively deepening process. Each step taken expands the base of knowledge – providing the opportunity to take the next step. Making progress on one line of inquiry (understanding one aspect of the field of practice) created the room to make progress on another.

The initial base of knowledge regarding PBA, and how practitioners function within it, was limited. A number of KE techniques were used to expand on and enrich the base understanding and evolve an ACWA model from which ideas for improved support could be generated. The selection of which technique(s) to use and how many techniques to employ was motivated by the need to produce a model of the field of practice and a model of how domain practitioners operate in that field. The modeling process generally requires the use of multiple converging techniques that include techniques that focus on understanding the domain demands as well as techniques that focus on understanding the knowledge and strategies of domain practitioners.

The KE process is highly opportunistic. The particular set of techniques that were selected were determined strongly by the pragmatics of the specific local conditions. Typically, access to domain practitioners is very limited. In these cases, other sources of domain knowledge (e.g. written documents) were maximally exploited before relying on domain experts. In some cases, observing domain experts in actual work practice (e.g., using ethnographic methods or simulator studies) may be impractical, and in those cases, using structured interview techniques may be the most practical method available. In cases where domain experts were not accessible at all (e.g., in highly classified government applications), looking for surrogate experts (e.g., individuals who have performed the task in the past) or examining analogous domains is necessary.

One key element of the KE is that it is performed iteratively with the ACWA effort. As interim results from the modeling task become available, they were used as material for further elicitation. The process of constructing the ACWA artifacts provided

requirements for the information needed to enrich the model. As an additional benefit, the Functional Abstraction Network (FAN) model has been shown to be extremely powerful in integrating seemingly disparate sources of information from a KE process into a unified analysis and design framework. Thus, the focus of the KE task was to, in an iterative and participatory manner, provide the data necessary to construct the set of ACWA artifacts. These artifacts and approaches were summarized in the WDAR.

The KE approach in this project specifically utilized a combination of methods. These included the following:

- Reviewing relevant technical documentation on PBA;
- Discussing with SMEs the difficult PBA scenarios and how they impact the decision-making process;
- Discussing with SMEs the FAN (and associated cognitive and information requirements) and its gaps in modeling the work domain; and
- Observing simulation and training exercises related to PBA in order to operationally validate (or negate) the analytical findings.

Appendix I contains the basic data collection plan for knowledge elicitations at user sites. The data collection plan leveraged the opportunistic nature of knowledge elicitations, thus the plan was not a rigid structured process, but rather a high-level guide from which deviations can be developed and pursued. Table 1 summarizes the KE details including interview sites, number of interviews and interviewees, date which the interviews occurred, and the perspective user's brought to PBA. The initial, planned data collections included the 608th AIS (Barksdale AFB) for a training and operational perspective; the 614th SIS (Vandenberg AFB) for a space operations perspective; and the 32nd AIS (Ramstein AFB) for a EUCOM perspective. These sites were selected to provide a cross-section of user and operational perspectives with respect to PBA. KE interviews spanned the entire project and provided valuable insight with respect to those users. Figure 1 provides a timeline for KE and other project related activities.

Table 1. KE site visit and briefing details (bold are original elicitation sites)

Site	Number of Interviews	Number of Interviewees	Date	User Perspective
AFC2ISR/INO	1	5	Mar '04	PBA Requirements WG – briefing
JFACC Mentors	1	2	Jun '04	Commander - Senior Decision-Makers
608th AIS, Barksdale AFB	8	15	Aug '04	Operations and Training
614th SIS, Vandenberg AFB	8	18	Sep '04	Space PBA
AOC Strategy Requirements WG	6	7	Sep '04	Strategy-focused PBA
32nd AIS, Ramstein AFB	4	4	Nov '04	Operational in-theatre, Joint and EUCOM
National Air and Space Intelligence Center (NASIC)	2	7	Mar '05	PBA via Users who issue responses to Information Requests
AF/XOIRB, Pentagon	1	3	May '05	AF office responsible for defining PBA requirements
609th AIS, CPS Shaw	2	7	Aug '05	Operational – current conflict experience
Total	**33**	**68**		

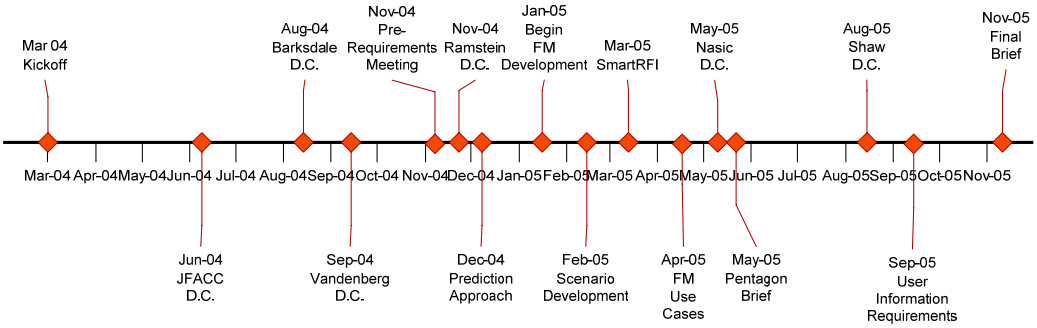

Figure 1. Timeline for KE site visit and project related activities

The team understood that opportunistic data collections would occur. Those collections were equally likely early in the project as late in the project. Furthermore, the dynamic nature and operational realities of user sites meant scheduling and executing the knowledge elicitations would be challenging. This was evidenced by several delays which pushed the planned initial data collection back several months.

3.2 User Requirements

The WDAR was focused on defining how PBA is used in the AOC. Defining user requirements via the WDAR ensured a solid starting point for PBA system specifications, e.g. information which the user needs in order to support working with PBA. These user-focused requirements were abstractions of cognitive work requirements and information relationship requirements identified in the WDAR and they served as a foundation for future system design.

3.3 Prediction Approaches

Two goals were established in refining project scope discussed in Section 2.2. The first goal was to obtain a clear understanding of the PBA domain. The second goal was to incorporate that knowledge into alternative "prediction model" concepts by leveraging team capabilities. Two baseline methods were pursued from which users could evaluate effectiveness and capabilities. These methods would serve as building blocks for future system enhancement and development.

Data collection delays, and the time required to process the data for the WDAR, meant the prediction methods had to be developed in parallel with requirements in order to meet briefing deadlines in which CDA4PBA would be compared to other more mature PBA-related programs.

The two alternative approaches rely on system models to make predictions about future events. One method, the Forecast Model (FM) is a collection of commercial off-the-shelf (COTS) and government off-the-shelf (GOTS) programs integrated through a single to-be technology. The alternate method, a Bayesian Belief Network (BNet) simulation, integrated a Bayesian Belief Network COTS program with a DARPA-developed

simulation to provide BNet estimations through an existing visualization framework environment.

3.3.1 Forecast Model Concept

The Forecast Model is one of two approaches investigated as a prediction methodology. The Forecast Model was proposed early in refining project scope and the concept was considered classic high-risk, high-reward. The concept is developed around COTS and GOTS technologies with the initial spiral establishing the underlying foundation.

Fundamentally, the Forecast Model searches analyst-specified intelligence sources for key words and maps that information into a knowledge base available to instantiate system models of interest. The technique comprises several technologies. The front-end includes an intelligence data processor which parses and stores word phrases in a knowledge base. These information elements, often from disparate sources, are related through a semantic reasoning engine so that items of specific interest, as well as "nuggets" of information deemed relevant, are brought to the analyst's attention.

A user at one operational site commented, "We spend an enormous amount of time trying to collate information from many different sources. In the end, we don't know whether all the appropriate (available) information sources were included. A system should bring us relevant information and we can then spend time conducting the analysis."

Further, relevant findings related in time and space are captured and presented to the analyst for possible action. These and the aforementioned findings may have been identified by the analyst, however, the Forecast Model leverages a computer's ability to quickly search and analyze data and compare many different sources for relevant information, a task not easily performed by analysts.

The prediction capability comes into play as knowledge base elements are instantiated against existing system models. In cases where a model does not exist, one can be created

and iteratively refined by parsing additional intelligence sources. After the model or models have been instantiated to the analyst's satisfaction, an estimate can be obtained.

The Forecast Model's high risk, high reward approach was pursued for several reasons. First, it supports Intelligence Preparation of the Battlespace (IPB) through analysis of the adversary, target system models, and enemy Courses of Action (COA). Second, a "forecasting" element is provided which provides the magnitude and range of error for estimations. Third, Intelligence, Surveillance, and Reconnaissance (ISR) management is supported, in that the Forecast Model can identify information which is unknown. Finally, the Forecast Model can be used to forecast the impact of friendly actions. The Forecast Model was an attractive prediction approach, because it would utilize tools and techniques that are currently available, although the process and effort required to combine these tools was yet to be determined.

3.3.2 Bayesian Belief Network Simulation Model

The Bayesian Belief Network (BNet) simulation is the second of two approaches investigated as a prediction methodology. The BNet concept is developed around COTS and Defense Advanced Research Projects Agency (DARPA) technologies and was proposed shortly after the Forecast Model as a quick-turn method for demonstrating predictive concepts via static causal analysis. The spiral one BNet approach provided a basic status capability that could serve as a test bed to demonstrate prediction capabilities and results through visualizations. This lower-risk approach yielded a foundation from which more advanced BNet-based prediction methodologies, such as temporal or dynamic belief networks, could be developed.

BNet was a powerful approach with respect to presenting the user decisional information. One challenge, however, is the technique requires an inordinate amount of subject-matter expertise in order to build the underlying models which drive the user information display. Considerable effort and revolutionary steps would potentially be required to simplify user interactions sufficiently to enable a typical user to identify, interpret, and input model data as well as build and maintain a model in the BNet environment. The

methodology requires updating the model with new information, when available, in order to improve predictions.

3.4 Smart Request For Information

The importance of information updates to the models became very apparent while developing the prediction approaches. Updating models requires understanding the environment. One facet of information updates that was reported frequently in the operational community was the “request for information” or RFI. An RFI may be issued when an operational question must be answered. A recurring theme from knowledge elicitations at operational sites was the ineffectiveness associated with executing an RFI, including both the method for issuing and the response. Two themes were developed. First was a solution to short-term RFIs or those requiring a quick response. These RFIs appeared to benefit most from a structured format for issuing and responding to RFIs. This approach would help the analyst to ask a better question and ensure the information is in a format which minimizes follow-up questions from a superior or responding organization. Second, a complementary procedure was identified which supports longer-term RFIs and the associated analysis process. This would, in part, be developed with knowledge management through ontology updates.

4 Findings and Results

Findings and products from each of the tasks described in Section 3 are described below with references to specific documents which contain the full analysis or documentation. These results helped form an understanding of the PBA operational environment.

4.1 Work Domain Analysis Report (WDAR)

The Work Domain Analysis Report (WDAR) presents and describes the results of Applied Cognitive Work Analysis (ACWA) of the Air & Space Command and Control work domain, focusing specifically on the functions and cognitive work that are accomplished within the functional scope of PBA. The state of the analytic artifacts was described in order to convey the structure of the analysis output and significant insights that were garnered. The WDAR for this project was focused on PBA, and as such, provided an extension of an existing WDAR encompassing Aerospace Command & Control. The document is located in 'CDA4PBA_WDAR_v1.4.pdf'.

The scope of the WDAR covers the cognitive work that is related to PBA, with special care to point out the cognitive work that is specific to responsible agents, such as the commander, as well as the cognitive work done by groups under their command, supporting their decisions, such as the intelligence group.

The WDAR occurred in two phases. The first phase which occurred during the first half of the project, produced an interim report and analysis focused on establishing a breadth of coverage, gaining a wide level of understanding across the domain. The WDAR interim report, however, lacked sufficient processing to yield the critical "user information requirements" necessary to make explicit decisions about what information should or should not be included in the methods, decision-support systems, and visualizations. The second phase allowed for a depth of coverage, which identified detailed cognitive work requirements and information relationships requirements related to PBA within various functions of the domain.

The WDAR contains detailed descriptions of the cognitive analysis generated using the ACWA process. The results of the modeling effort are discussed in terms of the twelve Goal-Process Nodes (GPNs) of the domain within the report's scope, listed as follows: "Successfully Manage Air & Space Objectives," "Successfully Manage Air & Space Effects," "Successfully Manage Air & Space Aims," "Successfully Infer Adversary/Others' Goals," "Successfully Infer Adversary/Others' Will," "Successfully Posit Adversary/Others' Capabilities," "Successfully Assess Adversary/Others' Behavior," "Successfully Manage Indicators," "Successfully Provide Intelligence Results," "Successfully Provide Applied Collection Power Findings," "Successfully Manage Attributes of Desired Subjects," and "Successfully Maintain the Inventory of "Subjects" (Targets) in the World." These nodes and the accompanying PBA scope are shown as part of the AC2 Functional Abstraction Network (FAN) in Figure 2.

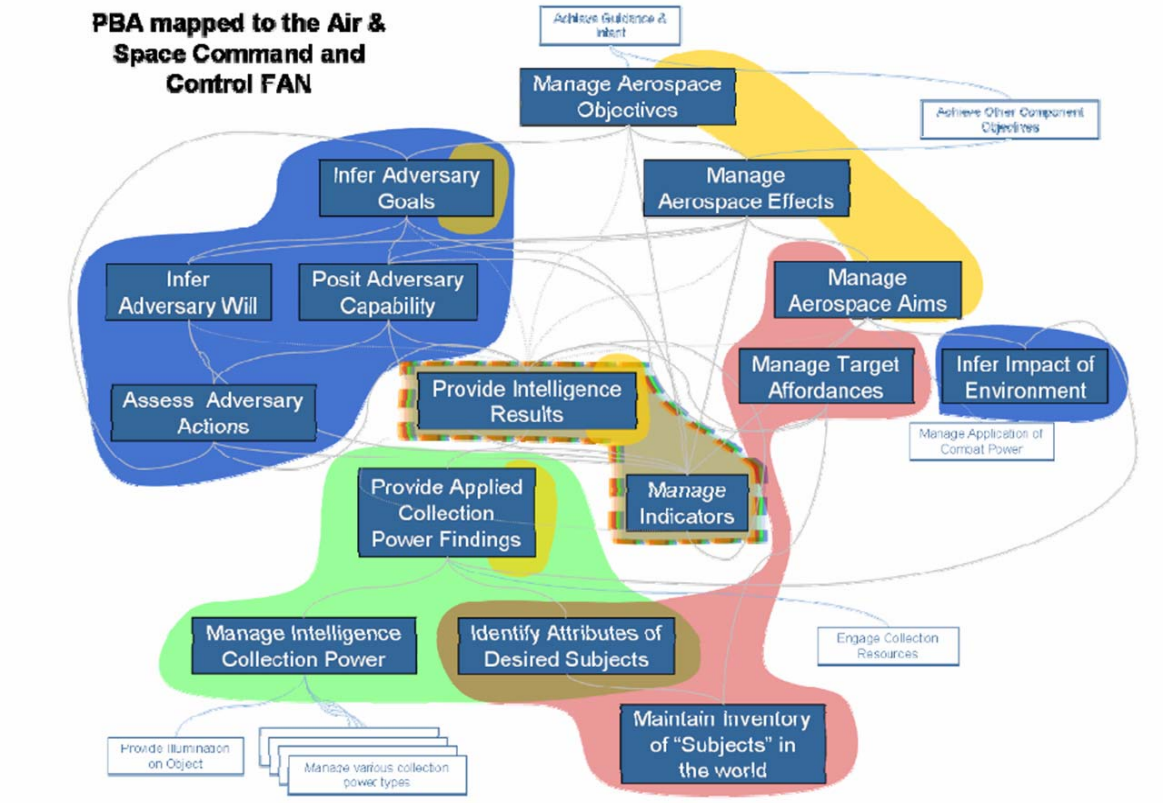

Figure 2. Twelve PBA Goal-Process Nodes in Air & Space Command and Control

The WDAR is divided into four sections:

Section A – Document description and project management material.

Section B – A brief tutorial for how to read and understand the contents of the WDAR. It starts with an overview of the ACWA methodology, and then continues to a high-level explanation of the artifacts of ACWA, which serve as the basis of analyses presented in Section C.

Section C – This section comprises the majority of the document and has two parts. The first part includes a general overview of the Functional Abstraction Network developed for the Strategy Division's work domain. It contains a brief explanation of the FAN and includes a "cartoon" and detailed version of the FAN, as well as an introduction to the four elemental scopes of PBA. The second part of this section is a node-by-node description of the in-scope GPNs that comprise the FAN. This part includes "Overview," "Goal," "Commodity," and "Process" sub-sections. Cognitive Work Requirements (CWR) and Information Relationship Requirements (IRR) tables follow up the description of the GPN, followed by a section to highlight the GPN's relationships to the concept of PBA.

Section D – A summary of the analytic effort for the CDA4PBA project is provided in this section.

Major findings from the WDAR can be summarized as follows:

"PBA is everywhere"

- The individual scopes of PBA (divided by doctrinally defined elements) could have been more encompassing by including a majority of the goal-process nodes for all sub scopes. However, the scopes were limited in their coverage in an attempt to get some functional traction within the PBA world. Just because there was a brief mention of a concept being concerned with a certain element of information or certain process, it was not automatically included in scope.
- Seeing all four PBA scopes on the AC2 FAN at once, gave the impression that PBA was to cover 'everything.' There is a desire to give the Commander the ability to monitor a large majority of cognitive work within the work domain, to provide the 'awareness' part of the PBA to them. However, to take this thin

amount of cognitive work (status monitoring) out of its functional context is to create more cognitive work because of the subjective division of a goal process node.

- There is no magic bullet for PBA; the coverage is so broad and encapsulates so many necessary decisions, that there is not a single way to support, let alone do PBA. It requires the coordination of many sets of decisions and decision makers to provide the results discussed with PBA.

Tighter Intelligence Coupling

- In the Interim WDAR, there was an interestingly large overlap of all scopes in the Intelligence Analysis region of the FAN (GPN 4.4 – Indicators and GPN 6.3 – Intelligence Results). The coding of these scopes was changed for this Updated WDAR, because in fact these functional processes do not belong in the scopes of PBA, whereas they are the KEY functional support to each goal-process that is associated with PBA. They were so important; that they were not decoupled until a further detailed inspection took place in the second half of the analysis period.
- This stresses the importance of tying cognitive work within the intelligence analysis goal processes to the conceptual PBA elements via the specific support-supported links between the GPNs in the FAN. The closer the relationship between Intelligence work and PBA work, the more accurate PBA predictions will be.

Status Understanding

- The Assessment Scope is found only on the second portion of several goal-processes within the domain. The current state of Blue (and other friendly) Forces, the current state of Adversary Forces and the current state of Gray Forces is information that would be desired by the Commander.
- The cognitive work that is required to understand, monitor and define the status of these various forces is a culmination point of decisions throughout many goals within the domain. The Commander may only be concerned about making decisions with the highest-level status they received to support the PBA scope of

Assessment. Nevertheless, countless other warfighters are providing the grist for the mill by doing the low-level decisions within the Air Force.

Cognitive Work Requirements - Responsible Agents

The focus of this project was to develop decision aids for the *Commander,* in support of PBA. This focus, incorporated with the understanding/insights above, meant three groups of 'Responsible Agents' were defined: **Commander**, **Support** and **Intelligence**, as a way to discern between the numerous CWRs and IRRs that were included in the PBA element scopes. An explanation of the three types follows.

The four PBA Scopes – Intelligent Preparation of the Battlespace, Target Development, ISR Strategy and Employment, and Assessment are each illustrated as an iceberg. The metaphor of the iceberg is used to illustrate that in actuality only a small portion of the total cognitive work related to each PBA Scope is found "above water," in this case the portion above the water represents the decisions that are being made by the **Commander**. The Commander's decisions, in general, are of the highest understanding and coverage – for example, the Commander would like to know the status of all of Blue Forces' desired effects, to get an understanding of the current state of effort. The commander would not want to hear details of how these assessments were derived.

The **Commander** tag is used when the Commander themselves or the Commanders staff is the responsible agent. Nevertheless, for the Commander to have this overall understanding of the effort, a culmination of various other decisions and information must support the Commander's decisions – the **Support**. To continue with the metaphor, an iceberg, without the underlying (underwater) support structure, would not be able to break the water's surface. Thus, without the **Support** cognitive work within each of the PBA scopes, the Commander's decisions would not be possible. An attempt to only support the Commander's decisions, without the context and support structure of the underlying cognitive work requirements would be inadequate support of PBA.

The third responsible agent for CWRs related to PBA is **Intel**. The CWRs and IRRs related to the intelligence process are not directly included in the scope of PBA, but are

significant in the successful execution of the PBA related cognitive work. The closer the relationship between the cognitive work within the Intelligence analysis and the cognitive work within the PBA scopes, the higher fidelity the PBA decisions.

The ACWA based analysis of cognitive work associated with PBA in the AC2 domain captured some significant insights into features necessary to support PBA in an AOC of the future. The proper design with the cognitive work identified and supported to successfully manage PBA will reduce the cognitive workload on the warfighter, not create a larger amount, as the warfighter is required to adjust to a decision support system.

Information from the May and August 2005 data collections could not be incorporated into the WDAR due to the substantial re-processing that was required. These data were noted by the project team and captured in a trip report.

4.2 User Requirements

One hundred and thirty-two high-level, user-focused PBA information and decision strategy requirements supporting the commander, analysts, and intelligence staff were identified and are listed by WDAR goal process node (GPN) in Appendix III. Again, the GPNs represent major decisions which occur in a PBA environment. Note these are initial user information requirements based on the Updated WDAR and should be validated by the user community prior to incorporating into a system design.

4.3 Forecast Model

The Forecast Model determines the likelihood of future model-based activities by searching available intelligence sources and instantiating that information in models. Another powerful feature is the analyst's ability to off-load time-consuming data-mining activities to the Forecast Model, leaving more time for the analyst to interpret findings discovered from these potentially disparate intelligence sources.

The Forecast Model begins with analysis of structured and unstructured text documents. Analysis is performed on words and phrases to extract meaning, context (structure), and

relationships (cause-effect through unknown). The mathematical models supporting analysis algorithms exist and some of the technologies exist. The spiral one approach was to develop the model specification within Enterprise Architect 5.0. Enterprise Architect enables one to develop Unified Modeling Language (UML) diagrams. UML is an industry-standard for specifying, visualizing, constructing, and documenting the artifacts of software systems. The UML Activity Diagram details the Forecast Model components, information flows, decisions, and requests for additional information. The entire model specification within Enterprise Architect is provided in a separate file (see FM Activity Diagram.rtf).

Although the model specification was described through activity and sequence diagrams, the process is complex, and as such required a thorough user-centered interface design. Visualization concepts were storyboarded to support and better explain user interactions with the Forecast Model. Capabilities specific to a user-centered design for non-technical users included 1) hiding the technical details of the process (transparency), 2) exposing additional detail upon a user's request (drill-down), and 3) clearly stating the rationale for determining outcomes. Achieving these three objectives is a step toward building a user's trust in operating a system which has significant and complex underlying mechanics. The Forecast Model was also a tool which could be used by the commander as well as his or her staff. Thus, views were tailored to support the information requirements for these two different user groups.

4.3.1 Activity Diagram

The Activity Diagram is shown in Figure 3 and represents a high-level view of system components and user interactions. This diagram served as a foundation for the type and order of user activities as well as system activities.

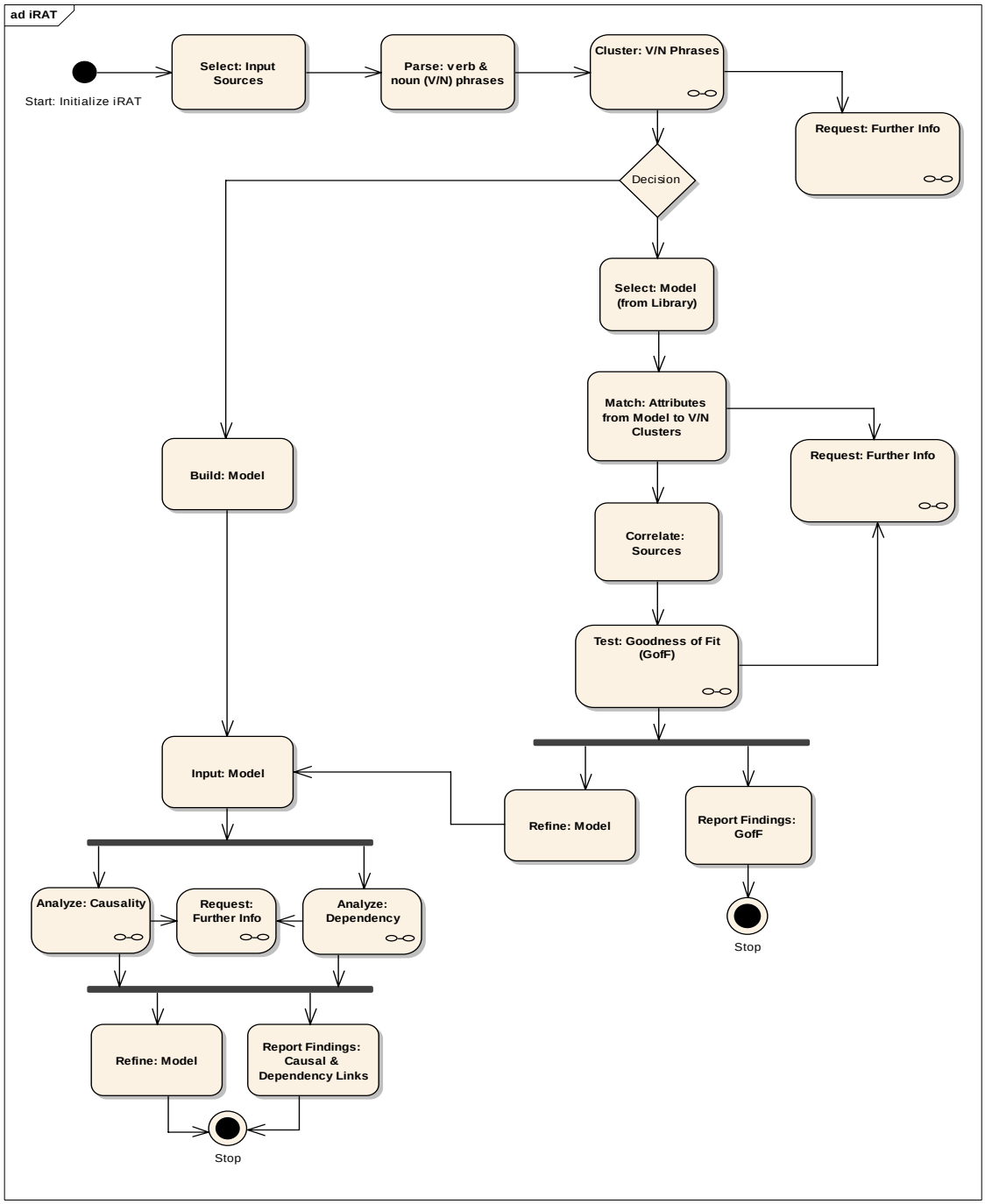

Figure 3. Forecast Model Activity Diagram

4.3.2 Use Cases

The next step following Model Specification was to develop use cases – the foundation for user interaction and a building block for developing software systems and prototypes. The use cases were kept at a high level since user information requirements had not yet been finalized. The use case descriptions, provided in Appendix II, were then used to generate storyboards and visualizations for several points in the Forecast Model user interaction process. The complete high-level use cases are contained in 'SRA User Interactions 13Jun05 v3.doc'.

4.3.3 Storyboard

Significant effort was involved in attempting to understand user interactions within the Forecast Model. While the use cases provided a high-level understanding of the Forecast Model, additional detail was required to complete concept visualizations. This detail was captured through a spiral interview process with the Forecast Model developer. The Forecast Model, however, was an evolving concept, and as such, user interactions and information requirements changed frequently.

Concept visualizations were particularly challenging, because the Forecast Model is based on a network of complex mathematical concepts and algorithms. A good user-centered design requires the user to access to these algorithms, when desired, and provide insight into how results are formulated. An analyst focused visualization concept for management of system models is shown in Figure 4. In this concept, the analyst has access to and manages relevant system models. Management includes updates or edits, as required, through inputs to both text and graphical formats. The analyst also has access to several views based on the type of analysis being conducted, e.g. correlating sources or determining the goodness of fit. Additional functions are available to the analyst within the Forecast Model environment including manipulating graphical models, retrieving a report, and issuing a Request For Information (RFI). (See 'FM new concept v1.5.2.ppt' for a storyboard of the FM process.)

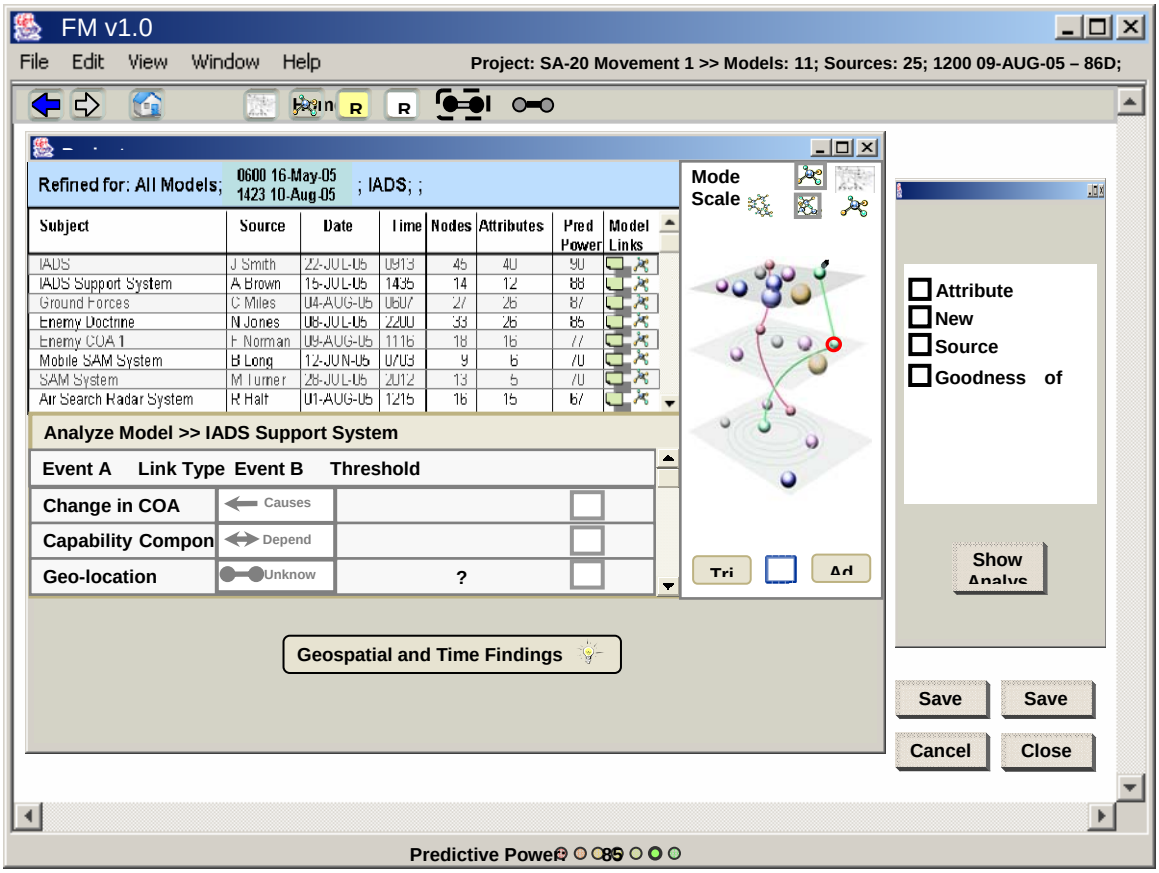

Figure 4. Analyst focused visualization concept for management of system models within the Forecast Model

4.4 Bayesian Belief Network Simulation

The goal for the spiral I prototype software was to demonstrate visualization concepts and provide a foundation from which Bayesian Belief Network prediction algorithms could be developed. Future spirals would extend the "static" Bayesian Network framework to temporal or dynamic models and thus provide a richer environment from which to build predictive capabilities. The prototype software used the Bayesian Belief Network engines within BNet Builder (COTS) overlayed with visualization concepts from a DARPA simulation effort (Context-driven Infospace Configuration for Augmented Cognitive Readiness – CIGAR).

The prototype served two purposes. First, it provided a means to demonstrate PBA visualization concepts tied directly to results generated through a Bayesian network (prediction) engine. Second, the prototype provided a means for a "quick-turn" demonstration to support a briefing at the Pentagon in which other more mature projects would be demonstrating the results of their efforts.

4.5 Smart Request For Information

The Smart Request For Information (SmartRFI) concept resulted from the need to support information exchanges and updates to both prediction model concepts, and the ISR system in general. Initial design concepts focused on identifying the essential elements of information (EEI) necessary to capture the requestor's intent. These EEIs formed an element of context. To quickly arrive at context, a structured RFI template was designed to help the requestor better focus the RFI and the responder better focus the effort (see Figure 5). Supporting context was an environment helping the requestor and responder conduct research with emphasis on searching related RFIs, a SME database, and building an Ontology or knowledge base from RFI exchanges.

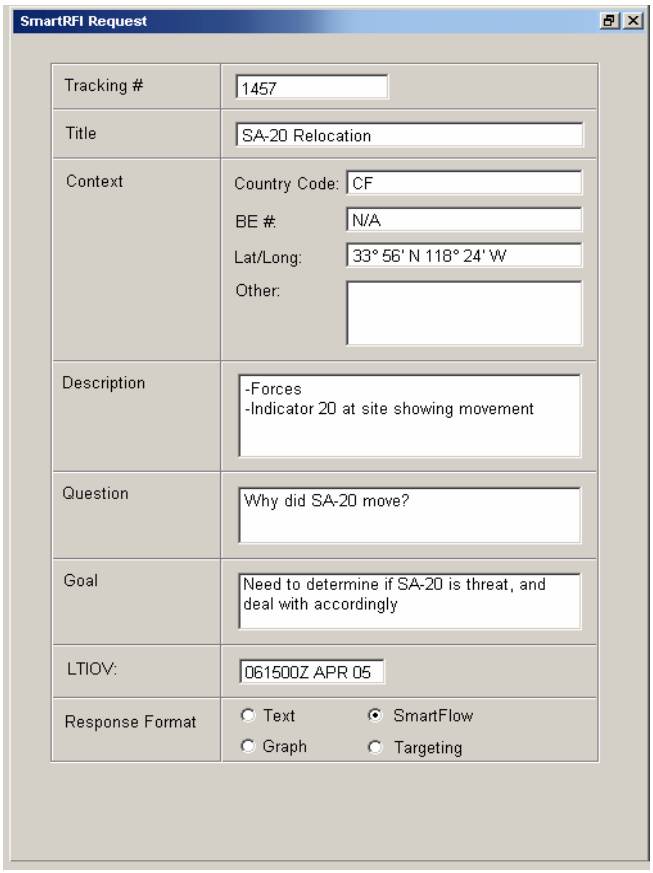

Figure 5. Initial conceptual design for standardizing an RFI and context

4.5.1 Design Concept Document

The SmartRFI Design Concept Document proposes an approach for implementing SmartRFI. The document is described as an enhancement to Coliseum in which additional functionality is considered, such as Tracking, Last Time Information Is of Value, Product Formats, building a knowledge base, and interfacing with Ontologies. The document does not consider interactions or communication with existing systems.

5 Findings

The CDA4PBA project resulted in several findings. First, a cognitive analysis was conducted across AOCs with varying missions; this yielded important information regarding prediction and PBA for commanders, intelligence staff, and support staff. The analysis, however, was focused on the Air Intelligence Squadron (AIS) or Space Intelligence Squadron (SIS) within each AOC. While these squadrons comprise the main users of PBA, and provided a good starting point for understanding PBA, other important users and consumers exist.

Second, information from interviews with SMEs, and the subsequent cognitive analysis, was used to generate an initial set of user-focused system and information requirements necessary to support PBA in an AOC environment. These requirements support the commander and his or her staff's main goals, with respect to using PBA information, and provide a framework from which a preliminary system design, including user interactions, can be developed.

Third, alternative (and potentially complementary) prediction approaches were developed in parallel with the lengthy and complex cognitive analysis. A spiral development plan was used for the two prediction approaches. However, funding limited this effort to one spiral.

The Forecast Model approach provided a foundation for the analysis of information leading to predictive capability. The technologies did not all exist and thus the concept was exploratory. User interactions and visualization concepts were also developed to expose the underlying capabilities.

The BNet simulation was a quick-turn product developed by integrating existing applications to provide a baseline from which predictive capabilities could be grown and from which visualization concepts could be demonstrated. The spiral one BNet simulation was driven by a static Bayesian Network engine and thus had no predictive

capability. Future spirals were designed to include temporal belief networks and thus include an element of prediction.

Fourth, a framework was developed for improving RFIs and capturing the knowledge therein. The framework was envisioned as a two-step process – one to support short-term RFIs and one to support long-term RFIs. Short-term RFIs benefit from a standardized RFI process to capture essential information elements. The inherent specificity provides a more precise and accurate request which subsequently enables a better, targeted response. Long-term RFIs are more analysis-focused and require slightly different information. A key feature for both RFI types is the ability to formulate context, i.e. provide the responder a basis for understanding why the request was written, what research had been conducted, and what product attributes the requester is most interested in, such as format, size, timeliness, and classification.

The evolution of user requirements and subsequent visualizations can be seen in ‘CDA4PBA Visualizations.ppt.’

6 Summary

The CDA4PBA project produced findings across a breadth of topics areas (with respect to PBA in a military operational environment, specifically an AOC). A number of activities could benefit from continued activity. The cognitive analysis was extensive with respect to the organizations interviewed, specifically the AIS and SIS. However, a more detailed understanding of PBA could be achieved if a larger cross-section of organization were considered, such as the Information Warfare Flight (IWF), Strategy, or Combat Plans. The additional analysis could also be used to support, modify, or create additional operational requirements.

The groundwork for a predictive capability has been formulated. Much work remains to fully prove these capabilities, however, initial incremental steps could determine whether the Forecast Model is viable or whether a temporal belief network model provides a usable predictive capability, particularly with respect to a user's ability to populate and operate the model. Finally, the need for an RFI support system was identified throughout all aspects of CDA4PBA. The ability to clearly and concisely state a problem, and in a manner which creates an environment of understanding for the responder, is a universal requirement.

7 Acronym List

AC2	Aerospace Command & Control
ACWA	Applied Cognitive Work Analysis (define 1st)
AFB	Air Force Base
AOC	Air & Space Operations Center
BNet	Bayesian Belief Network
CDA4PBA	Commander's Decision Aid for Predictive Battlespace Awareness
CIGAR	Context-driven Infospace Configuration for Augmented Cognitive Readiness
COA	Course of Action
COTS	Commercial Off-The-Shelf
CPS	Combat Plans Squadron
CTA	Cognitive Task Analysis
CWA	Cognitive Work Analysis
CWR	Cognitive Work Requirement
DARPA	Defense Advanced Research Projects Agency
EEI	Essential Element of Information
EUCOM	European Command (define 1st)
FAN	Functional Abstraction Network
FM	Forecast Model
GOTS	Government Off-The-Shelf
GPN	Goal-Process Node
IRR	Information Relationship Requirement
ISR	Intelligence, Surveillance, and Reconnaissance
IWE	Information Warfare Effectiveness
JFACC	Joint Forces Air Component Commander
KE	Knowledge Elicitation
PBA	Predictive Battlespace Awareness
RFI	Request for Information
SmartRFI	Smart Request for Information
SME	Subject-Matter Expert
SRA	SRA International, Inc.
UML	Unified Modeling Language
USAF	United States Air Force
WDAR	Work-Domain Analysis Report (define 1st occurrence)

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Appendix I: CDA4PBA Knowledge Elicitation Methodology

Introduction

The objective of our Knowledge Elicitation (KE) is to gather, through a combination of methods, a complementary set of information about the decision-making problem space under consideration. Typically, the work domain analysis is performed based on a variety of KE activities. This involves interactions with expert practitioners in the domain and includes face-to-face interviews with the experts, watching the experts work in the domain, verbal protocol techniques, and other Cognitive Task Analysis (CTA) and Cognitive Work Analysis (CWA) methods (cf. Potter, Roth, Woods & Elm, 2000; Vicente, 1999). In practice, this is an iterative, progressively deepening process.

The phrase 'bootstrapping process' has been used to describe this process and emphasize the fact that the process builds on itself (Potter, et al., 2000). Each step taken expands the base of knowledge providing opportunity to take the next step. Making progress on one line of inquiry (understanding one aspect of the field of practice) creates the room to make progress on another. One starts from an initial base of knowledge regarding the domain and how practitioners function within it (often very limited). One then uses a number of KE techniques to expand on and enrich the base understanding and evolve an ACWA model from which ideas for improved support can be generated. For example, one might start by reading available documents that provide background on the field of practice (e.g., training manuals, procedures), the knowledge gained will raise new questions or hypotheses to pursue that can then be addressed in interviews with domain experts, it will also provide the background for interpreting what the experts say. In turn, the results of interviews or exercises may point to complicating factors in the domain that need to be modeled in more detail in the FAN. This provides the necessary background to create scenarios to be used to observe practitioner performance under simulated conditions or to look for confirming example cases or interpret observations in naturalistic field studies.

The selection of which technique(s) to use and how many techniques to employ is motivated by the need to produce a model of the field of practice and how domain practitioners operate in that field. In practice the modeling process generally requires the use of multiple converging techniques that include techniques that focus on

understanding the domain demands as well as techniques that focus on understanding the knowledge and strategies of domain practitioners. The KE process is highly opportunistic. The particular set of techniques selected will be strongly determined by the pragmatics of the specific local conditions. Typically, access to domain practitioners is limited. In that case other sources of domain knowledge (e.g. written documents) can be maximally exploited before turning to domain experts. In some cases observing domain experts in actual work practice (e.g., using ethnographic methods or simulator studies) may be impractical, in those cases using structured interview techniques may be the most practical methods available. In cases where domain experts are not accessible at all (e.g., in highly classified government applications), it becomes necessary to look for surrogate experts (e.g., individuals who have performed the task in the past) or analogous domains to examine.

One key element of the Knowledge Elicitation is that it is performed iteratively with the ACWA effort. As interim results from the modeling task become available, they will be used as material for further elicitation. The process of constructing the ACWA artifacts provides requirements for the information needed to enrich the model. As an additional benefit, the Functional Abstraction Network model has been shown to be extremely powerful in integrating seemingly disparate sources of information from a KE process into a unified analysis and design framework. Thus, the focus of this KE task is to, in an iterative and participatory manner, provide the data necessary to construct the set of ACWA artifacts.

As mentioned above, our KE approach will utilize a combination of methods to achieve the desired result. These will need to include:

- Reviewing relevant technical documentation on PBA;
- Discussions with SMEs on difficult PBA scenarios and how they impact the decision-making process;
- Discussions with SMEs on our FAN (and associated cognitive and information requirements) and its gaps in modeling the work domain; and
- Observations of simulation and training exercises related to PBA in order to operationally validate (or negate) the analytical findings.

These different activities are laid out in the following plan.

KE Data Collection Plan

Each of the steps in our ACWA methodology is 'fed' by a variety of Knowledge Elicitation activities. This will involve interactions with expert practitioners in the domain in a variety of forms (e.g., face-to-face interviews, unstructured observations in actual work situations, and structured observations in simulated conditions). We will utilize a combination of staff and consultant subject matter experts to complement 'in the field' KE data collection activities.

The focus of the KE effort will be to:

- Gain familiarization and understanding of the goals and cognitive work requirements;
- Ground this understanding in terms of the decision-maker's work context; and
- Gain a solid understanding of the actual work that is required to conduct and maintain the PBA process.

Initial Familiarization

This phase consists of reviews of related documentation (including training material, system descriptions, and operational scenarios), initial interviews with SMEs, and task walkthroughs. These activities provide the background knowledge to understand the tasks to be performed by the operators and their comments, but typically do not provide the critical insights into what makes the decision-making especially difficult.

The accompanying list of documentation itemizes the material we have available for literature review. We will need SMEs to review this list and provide additional documentation for use in the initial familiarization phase.

In addition, we will need a one or two day meeting with an SME from the work team to provide initial insights to guide our activities.

Initial Functional Modeling of the Domain

Based on the above, an initial functional model of the problem space can be developed. This provides a starting point for understanding fundamental relationships, scope of the problem space to be modeled, and essential objectives. Even an initial austere representation can convey the structure of entities that relate to more abstract concepts.

Most importantly, this representation provides a framework for preparing for future interviews (based on gaps in the initial functional model) as well as interpreting results of those interviews and observations and integrating those results into a unified, well-grounded representation.

We will need occasional meetings (mostly telecon with possible face-to-face) with an SME from the work team to provide initial feedback and insights to our analysis activities.

Interviews with Subject Matter Experts

Based on the initial model, areas for further investigation can be identified which frame the lines of questioning to be pursued. These interviews then focus on understanding the factors in the domain that makes the particular tasks difficult and the knowledge and skill requirements for expert performance. These interviews can take a variety of forms:

- One-on-one interviews with SMEs where the format follows a question-and-answer approach; or
- Group interviews or 'expert panel' sessions where the format focuses on facilitating discussions between the multiple SMEs to highlight different perspectives to the problem.

Therefore, we are flexible with respect to the specific availability of the SMEs. In general, 'in the field' KE events are scheduled for 2-4 days, depending on the specific availability of the SMEs. If the set is available as a single group, the event should be only 2 days. However, if the set is available individually, the event should be longer in order to accommodate this schedule. The specific scheduling of these interviews will depend primarily on the availability of the SMEs.

With respect to the SME needs, in general the SME requirements include:

- Operationally current practitioners who have a deep understanding of the processes and the underlying basis for these processes;
- Tactics / doctrine experts;
- Instructors within the specific problem space.

We will need an SME from the work team to attend these interviews and provide 'translation services' for unfamiliar domain specific concepts.

Interim Functional Modeling

The results of the above tasks will be used as refinements and expansions to the ACWA artifacts that were developed earlier. This analysis effort will provide the decision-centered framework for additional KE activities. Specifically, the focus often shifts to the design of scenarios to be potentially included in the observation-focused KE activities.

We will need occasional meetings (mostly telecon with possible face-to-face) with an SME from the work team to provide initial feedback and insights to our analysis activities.

Observation of Performance in Simulated Conditions

With the baseline knowledge acquired in the first three phases, a valuable complementary KE activity is the observation of behavior under realistic dynamic conditions. This can provide converging evidence of the validity and effectiveness of the strategies they described during the interview sessions. This can also provide an opportunity to reveal additional expert strategies that were triggered by the context of actual task performance that might otherwise have remained inert. Ideally this involves some level of control over the scenarios presented to the operators.

We will need an SME from the work team to attend these interviews and provide 'translation services' for unfamiliar domain specific concepts.

Appendix II: CDA4PBA Forecast Model Use Case Descriptions

The forecast model (FM) is a process for populating and updating one or more selected military models and instantiating or constructing those models with intelligence information. The degree to which intelligence information fits the models determines how "good" the FM prediction is. (Note: "good" from the viewpoint of being supported by data. An assumption is made that the input models are valid and accurate.)

FM processing results in 1) RFIs issued based on geo-spatial, temporal and semantic quality information and 2) useful information containing which otherwise may not have been processed due to a lack of context.

The basic sequence of activities starts with a commander requesting an update to the "forecast" for a specific event. The event has already been identified, for example a trigger event is formulated in the plan. Information sources such as USMTF or WSV are selected to support the event. A semantic search (noun/verb phases in context) is conducted on the information sources and results are stored in a database. Noun/verb phrases are correlated in space (geo-location) and time (temporal). Models are created or updated and information source processing continued to iteratively develop the models. Match attributes. A graphical model is developed. The model(s) are evaluated for causal relationships (correlated links are converted to causal where evidence suggests it is appropriate). The model(s) are further evaluated for dependency relationships (correlated links are converted to dependency where evidence suggests it is appropriate). Throughout this process, RFIs are issued and analyzed to further refine the model(s). A Goodness of Fit (GOF) test is performed at any point in the process and on any subset of links/nodes therein.

The high-level use case descriptions are provided below. The details associated with each use case are contained in the file 'SRA FM User Interactions 13Jun05 v3.doc'.

Use Case 1 – Analyst selects intelligence information inputs for FM processing

Context: The analyst must identify information sources relevant to the Commander's request.

Goal: The analyst selects information sources (Intel or other information) to either *instantiate or construct* the event model(s).

Success: Information sources have been selected for FM processing.

Use Case 2 – Analyst selects model information for FM processing

Context: The analyst must identify Models relevant to the Commander's request.

Goal: The analyst selects Model(s) appropriate for the trigger event.

Success: Models have been selected for FM processing.

Use Case 3 – Analyst selects model attribute information for FM processing

Context: The analyst must identify Model Attributes relevant to the Commander's request.

Goal: The analyst selects Model Attributes appropriate for the trigger event.

Success: Model Attributes have been selected for FM processing.

Use Case 4 – FM processing step to associate trigger event Attributes with Intel

Context: FM 1) matches Model attributes to data in the selected Intel reports and 2) correlates "other data elements" in time and space.

Goal: Match Model Attributes to those found in Intel and identify data correlations in time and space.

Success: Depends upon Goodness of Fit results.

Use Case 5 – Goodness of Fit test between trigger event Attributes and Intel data

Context: The Goodness of Fit (GOF) can be conducted at any point in the process, on the Model or Attributes, and on any subset thereof. This step quantifies how well Model Attributes match data in the selected Intel reports. Isolating the Model for a GOF can help in issuing and ranking RFIs. Smart RFIs are issued to 1) improve link quality, 2) identify "unknown" information, 3) add to the

Model or Attributes, and 4) add to or improve pre-processing results (quantity or quality).

Goal: Match Model Attributes to those found in Intel reports.

Success: Goodness of Fit meets or exceeds user-specified criteria. The "best" Model is selected.

Use Case 6 – Build graphical model of causal, dependency and correlation relationships

Context: Build the GM and populate with data found in the Intel reports. Analyze the Model for True (genuine), Potential (probably), Spurious associations, and Unknown Causal relationships (links) as well as Dependency relationships for unobserved (latent) and observed nodes. Causal relationships provide: 1) a sequence in time, i.e., A must happen before B, if A causes B, 2) the state of one node causes a change in state of another node, and 3) causal implies a dependency relationship (no loops though).

Goal: Interpret the GM with respect to Causal and Dependency relationships

Success: User understands extent and magnitude of Causal and Dependency relationships.

Use Case 7 – Discrete Event Simulator (DES) to forecast at a specific point in time

Context: Run the GM through a DES to determine when forecast will occur and information requirements which may be necessary to support the forecast.

Goal: Understand within model-determined confidence limits when the forecast will occur.

Success: User provides a forecast with an overall confidence level.

Appendix III: CDA4PBA Operational Requirements per the WDAR

GPN 1.1 Successfully Manage Air & Space Objectives

Req ID	Requirement	Agent
1.1-01	The system shall display the focus of individual Air & Space Objectives over time	Support Staff
1.1-02	The system shall display the focus of the entire set of Air & Space Objectives over time	Support Staff
1.1-03	The system shall display the relationships between Air & Space Objectives	Support Staff
1.1-04	The system shall display the expected Air & Space Objective satisfaction/end time	Commander Staff
1.1-05	The system shall display the expected Air & Space Objective satisfaction/end time in parallel with the actual satisfaction state	Commander Staff
1.1-06	The system shall display the amount of risk in completing individual Air & Space Objectives based on the current situation	Support Staff
1.1-07	The system shall display the confidence in the ability to complete the individual Air & Space Objectives by the estimated end time.	Support Staff
1.1-08	The system shall display any changes in guidance and intent over time	Support Staff
1.1-09	The system shall display the achievement/completion status for individual objectives over time	Commander Staff
1.1-10	The system shall display the actual achievement/completion status for individual objectives in parallel to projected achievement/completion status over time	Commander Staff
1.1-11	The system shall display the confidence in the assessments of the individual Objective's statuses.	Commander Staff
1.1-12	The system shall display the valuated indicators that have been bundled for each Air & Space Objective	Commander Staff
1.1-13	The system shall display the reliability and the timeliness (its utility) of each indicator within a specific Air & Space Objective's bundle.	Support Staff

GPN 2.1 Successfully Manage Air & Space Effects

Req ID	Requirement	Agent
2.1-01	The system shall display the relationships and dependencies (sequential, temporal and simultaneous) between the entire Air & Space Effects network.	Commander Staff
2.1-02	The system shall display the achievement/success status of each Air & Space Effect within the context of all other Effects' status over time.	Commander Staff
2.1-03	The system shall display the priority of each Air & Space Effect within the entire set	Commander Staff

2.1-04	The system shall display the weight of each of the Air & Space Effects' status as they support the Air & Space Objectives status	Commander Staff
2.1-05	The system shall house an algorithm that provides the "overall score" of the Air & Space Effect Network	Support Staff
2.1-06	The system shall display the "overall score" in parallel with the set of individual Effects' status that make up the "overall score".	Commander Staff
2.1-07	The system shall display the linkage between the Air & Space Effects and specific posited adversary capabilities	Commander Staff
2.1-08	The system shall display the linkage between the Air & Space Effects and specific inferred adversary will	Commander Staff
2.1-09	The system shall display the reliability and the timeliness (its utility) of each indicator within a specific Air & Space Effect's bundle.	Support Staff
2.1-10	The system shall display the resource cost for the potential collection of each indicator within a specific Air & Space Effect's bundle.	Support Staff
2.1-11	The system shall allow the user to prioritize the indicators within a specific Air & Space Effect based on their utility and by the number of times a single indicator is used for multiple Effects.	Support Staff
2.1-12	The system shall display the number of times an indicator is used across the entire Air & Space Effect network.	Support Staff
2.1-13	The system shall display the achievement/success status of each Air & Space Effect as it is supported by the execution/success status (or lack thereof) of related Air & Space Aims.	Commander Staff
2.1-14	The system shall display adversary capability level prior to Air & Space Aim execution	Commander Staff
2.1-15	The system shall display the degree of projected degredation to the adversary capability after the Air & Space Aim execution	Commander Staff
2.1-16	The system shall display the rate in which the adversary can reconstitute a specific adversary capability	Support Staff

GPN 3.1 Successfully Manage Air & Space Aims

Req ID	Requirement	Agent
3.1-01	The system shall display the execution status of the entire set of Aims over time.	Commander Staff
3.1-02	The system shall display the planned execution time for each individual Aim in coordination with the actual execution time for each individual Aim.	Commander Staff
3.1-03	The system shall display the success status of the entire set of Aims over time.	Commander Staff

3.1-04	The system shall display the actual execution status for each individual Aim.	Commander Staff
3.1-05	The system shall display the relationship between the Air & Space effects and each individual aim	Support Staff
3.1-06	The system shall display the execution status of the Aims related to a specific Air & Space effect's success status.	Commander Staff
3.1-07	The system shall display the success status of the Aims related to a specific Air & Space effect's success status.	Commander Staff
3.1-08	The system shall display the target's affordances, the types of combat power that would be effective against it and the availability of all types of Air & Space Combat Power	Support Staff

GPN 3.2 Successfully Infer Adversary Goals

Req ID	Requirement	Agent
3.2-01	The system shall display the success status of adversary goals over time	Commander Staff
3.2-02	The system shall display the current indicator set and their status as related to the success status of each adversary goal	Support Staff
3.2-03	The system shall display the completion status of adversary goals over time	Commander Staff
3.2-04	The system shall display the estimated progress of the adversary toward their goals along with the end state of their inferred goals	Commander Staff
3.2-05	The system shall display the delta between expected progress and actual progress towards an inferred adversary goal	Commander Staff
3.2-06	The system shall display the temporal delta between expected progress and actual progress towards an inferred adversary goal	Commander Staff
3.2-07	The system shall show the relationships between the inferred adversary goals and the assumed adversary will (by societal group that applies)	Commander Staff
3.2-08	The system shall show the relationships between the inferred adversary goals and the inferred adversary capabilities (by capability types that apply)	Commander Staff
3.2-09	The system shall show changes to assumed adversary will as they relate to the inferred adversary goals.	Commander Staff
3.2-10	The system shall arrange the inferred adversary goals in order of their potential ability to prevent Air & Space objectives	Commander Staff
3.2-11	The system shall arrange the inferred adversary goals in order of their potential ability to enable Air & Space objectives	Commander Staff

GPN 3.3 Successfully Assess Adversary Behaviors

Req ID	Requirement	Agent
3.3-01	The system shall illustrate the actual adversary behavior in contrast to the expected adversary behavior over time.	Commander Staff
3.3-02	The system shall display the difference between the time of actual adversary behavior in line with the time of expected adversary behavior.	Commander Staff
3.3-03	The system shall provide the user with the ability to assign metrics for determining the supporting nature between adversary behavior and adversary capabilities.	Commander Staff
3.3-04	The system shall provide the user with the ability to assign metrics for determining the supporting nature between adversary behavior and adversary will.	Commander Staff
3.3-05	The system shall display the correlation between adversary behavior and adversary capabilities over time.	Commander Staff
3.3-06	The system shall display the correlation between adversary behavior and adversary will over time.	Commander Staff
3.3-07	The system shall display the relationships between the adversary behavior and the inferred adversary goals while displaying the adversary goals' success status.	Commander Staff
3.3-08	The system shall display the assessed adversary behavior events along side of the execution status of Air and Space Aims.	Support Staff
3.3-09	The system shall display the estimated relationship strength between an adversary behavior and Air & Space Aims.	Support Staff
3.3-10	The system shall track the accuracy of the expected adversary behavior compared to the actual adversary behavior	Commander Staff
3.3-11	The system shall provide a means for the user to illustrate the expected adversary behaviors as they are derived from inferred adversary goals by their hierarchical/organizational relationships	Support Staff
3.3-12	The system shall provide a means for the user to illustrate the expected adversary behaviors as they are derived from inferred adversary goals by the position of adversary forces in parallel with Air & Space Forces.	Support Staff
3.3-13	The system shall provide a means for the user to illustrate the expected adversary behaviors as they are derived from inferred adversary goals by their sequential/temporal relationships	Support Staff
3.3-14	The system shall display the observed adversary behavior differently than the expected adversary behavior.	Support Staff

3.3-15	The system shall allow the user to link intelligence results regarding motivation for expected and observed adversary behavior.	Support Staff

GPN 3.4 Successfully Posit Adversary Capabilities

Req ID	Requirement	Agent
3.4-01	The system shall display the entire posited capability network.	Support Staff
3.4-02	The system shall distinctly display the various types of inferred adversary capabilities (Political, Military, Economic, Social, Informational, Infrastructure, Humanitarian, etc)	Support Staff
3.4-03	The system shall display the linkage between assessed adversary behaviors/actions which demonstrate certain capabilities	Support Staff
3.4-04	The system shall allow the user to enter and track a confidence level for inferences made about each type of adversary capability over time.	Support Staff
3.4-05	The system shall allow the user to tie inferred adversary capabilities with supporting Intel results	Support Staff
3.4-06	The system shall show the degree to which the posited adversary capabilities support the achievement of adversary goals.	Commander Staff
3.4-07	The system shall show the relationship between the posited adversary capabilities and the Air & Space Effect's network	Commander Staff
3.4-08	The system shall provide the relevance of assessed adversary behaviors as related to inferred capabilities.	Support Staff
3.4-09	The system shall provide the quality of evidence that supports the relevance rating given to the relationships between adversary behaviors and inferred capabilities.	Support Staff
3.4-10	The system shall alert the user when new intelligence results, specific to adversary capabilities or capability type, are ready to be reviewed.	Support Staff
3.4-11	The system shall track the use of specific capabilities over time.	Support Staff
3.4-12	The system shall track changes in effectiveness of specific capabilities over time.	Support Staff
3.4-13	The system shall track changes in efficiency of system of specific capabilities over time.	Support Staff
3.4-14	The system shall show the age of specific adversary capabilities over time.	Support Staff

GPN 3.6 Successfully Infer Adversary Will

Req ID	Requirement	Agent
3.6-01	The system shall display the number and identity of Air & Space Effects that were created based on inferences regarding adversary will.	Commander Staff

3.6-02	The system shall track the actor(s) (individual, group, organization, etc) whose will is being monitored as related to specific Air & Space Effects.	Commander Staff
3.6-03	The system shall monitor the coherence of will across the specific actor(s) (individual, group, organization, etc) as related to specific Air & Space Effects.	Commander Staff
3.6-04	The system shall display the degree to which an inferred adversary will could (hypothesized) prevent an Air & Space Effect.	Commander Staff
3.6-05	The system shall display the degree to which an inferred adversary will could (hypothesized) enable an Air & Space Effect.	Commander Staff
3.6-06	The system shall display changes in the strength of the adversary's will in parallel with the execution and success status of Air & Space Effects over time.	Commander Staff
3.6-07	The system shall provide the means to tie intelligence results to any point in time when the changes in strength occur.	Support Staff
3.6-08	The system shall provide the means to search through historical sources based on the attributes of the current conditions	Support Staff
3.6-09	The system shall display the relationships between the will of multiple segments of society (Political leadership, Military leadership, Front Line soldiers, civilian population soldiers, etc.) over time.	Support Staff
3.6-10	The system shall provide the status of the will of the Political Leadership over time.	Commander Staff
3.6-11	The system shall provide the status of the will of the Military Leadership over time.	Commander Staff
3.6-12	The system shall provide the status of the will of the Front Line soldiers over time.	Commander Staff
3.6-13	The system shall provide the status of the will of the civilian population soldiers over time.	Commander Staff
3.6-14	The system shall display the level of risk the adversary is willing to assume, organized by societal segment.	Commander Staff
3.6-15	The system shall provide the means to link specific intelligence results with assumptions made about the adversary will.	Support Staff

GPN 4.4 Successfully Manage Indicators

Req ID	Requirement	Agent
4.4-01	The system shall display and arrange the Indicators based on their relevancy to current Air & Space Objectives.	Intel
4.4-02	The system shall display and arrange the Indicators based on their relevancy to current Air & Space Effects.	Intel

4.4-03	The system shall display and arrange the Indicators based on their relevancy to current Adversary Goals.	Intel
4.4-04	The system shall display and arrange the Indicators based on their relevancy to current Adversary will.	Intel
4.4-05	The system shall display and arrange the Indicators based on their relevancy to current Adversary Capabilities.	Intel
4.4-06	The system shall display and arrange the Indicators based on their relevancy to current Adversary Behavior.	Intel
4.4-07	The system shall display the 1 to many number of uses an indicator may have across a plan	Intel
4.4-08	The system shall allow the user to view the assessments of an indicator's quality over time	Intel
4.4-09	The system shall allow the user to establish a maximum time duration threshold for an indicator's quality since it was last assessed.	Intel
4.4-10	The system shall display the amount of time since the indicator's quality was last assessed.	Intel
4.4-11	The system shall provide an average fulfillment time estimate for the collection of information to valuate all indicators within a bundle.	Intel
4.4-12	The system shall provide a resource cost estimate for the collection of information to valuate all indicators within a bundle.	Intel
4.4-13	The system shall display the coverage a new indicator shall provide in parallel with the current indicator's coverage for the item (Adv. Goal, Objective, Effect, etc) in question.	Intel
4.4-14	The system shall display the priority and criticality of the selected plan element in question (Objective, Effect, etc).	Intel
4.4-15	The system shall provide a history of use (frequency, level of plan, last date of use) for any indicator that has been used previously.	Intel

GPN 6.3 Successfully Manage Intelligence Results

Req ID	Requirement	Agent
6.3-1	The system shall display the success status of each Intelligence Requests as it corresponds to the priority driven by the Commander's intent	Commander Staff
6.3-2	The system shall allow the user to select the temporal duration to view the success status of the entire set of Intelligence Requests (hourly, daily, weekly, etc)	Commander Staff
6.3-3	The system shall allow the user to enter new Intelligence Requests or revise existing Intelligence Requests to increase the clarity of the request	Support Staff
6.3-4	The system shall show the collection plan in contrast to the intelligence requests' priority	Support Staff

6.3-5	The system shall allow the user to assign an uncertainty (percentage) of an intelligence result as a function of the clarity of the Intelligence Request	Support Staff
6.3-6	The system shall display the relationship between each intelligence result as it relates to entire set of intelligence requests.	Commander Staff
6.3-7	The system shall allow the user to prioritize "requests for analysis" based on the Commander's requests.	Support Staff
6.3-8	The system shall group the Intelligence Requests based on the country in question's Master, Monitor and Measure classification.	Support Staff
6.3-9	The system shall show the time pressure (pressure to complete intelligence analysis) on each individual Intelligence Requests.	Support Staff
6.3-10	The system shall direct emphasis on Intelligence Requests that correlate with analysts' specialized knowledge bases.	Intel
6.3-11	The system shall display the initial request time and the expected completion time for each Intelligence Request.	Intel
6.3-12	The system shall display the expected completion time in contrast to the actual completion time for each Intelligence Request.	Support Staff
6.3-13	The system shall provide a means to search the intelligence results before tasking a new collection effort.	Support Staff

GPN 7.4 Successfully Provide Applied Collection Power Findings

Req ID	Requirement	Agent
7.4-01	The system shall allow the user to prioritize their available intelligence assets based on their collection effectiveness	Support Staff
7.4-02	The system shall portray the quantity of available collection power assets over time.	Support Staff
7.4-03	The system shall portray the quantity of committed collection power assets over time.	Support Staff
7.4-04	The system shall show the amount of collection power available in contrast to the committed collection power assets.	Support Staff
7.4-05	The system shall portray the selected subject's location as it relates to the proximity of the available collection power assets.	Support Staff
7.4-06	The system shall show the trade offs between potential collection power assets and selected subject attributes options.	Support Staff
7.4-07	The system shall indicate what current available collection power assets are deemed "unusable" based on environmental variables.	Support Staff

7.4-08	The system shall display which, out of the entire set of Intelligence Requests, are currently being collected against.	Commander Staff
7.4-09	The system shall track the total number of collections against each individual Intelligence Request.	Commander Staff
7.4-10	The system shall portray the life cycle (from planned, to execution, to end/return time) of a collection.	Support Staff
7.4-11	The system shall provide the capability for the user to re-task a collection if the subject attribute - collection power pair is no longer current	Support Staff
7.4-12	The system shall provide the capability for the user to re-task a collection if the related Intelligence Request's priority has changed.	Support Staff

PART II: CENTER OF GRAVITY VISUALIZATION REPORT

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Introduction

Requirements elicitations during the Commander's Decision Aid for Predictive Battlespace Awareness (CDA4PBA) project uncovered a need for better ways to request and obtain information (see Section 3.4, Smart RFI) and better ways to visualize information for effects-based center of gravity (COG) analysis. That effort led to the *Center of Gravity Visualization* (COG Viz) project.

COG Viz project was initially conceived as a preliminary investigative effort to identify potential tools and methods to enhance, in both speed and accuracy, center of gravity analysis. Activities conducted under COG Viz included a literature survey, COG tools and methods comparison and gap analysis, elicitations at the Warfighter Analysis Workshop, and baseline requirements development. The baseline requirements and analytical insights gained became the foundation for a second, and broader, effort, *Visualization for Operational Environment Understanding and Response* (VOEUR) which is ongoing at the time of this writing.

Center of Gravity Visualization (COG Viz)

The COG Viz project objective was to facilitate predictive battlespace awareness through visualizing adversary and friendly centers of gravity in order to support mission planning decision-making prior to and during execution. For purposes of this effort, centers of gravity were defined as *"those characteristics, capabilities, or sources of power from which a military force derives its freedom of action, physical strength, or will to fight"* (Joint Publication 1-02, Department of Defense Dictionary of Military and Associated Terms). The basic COG process (Figure 1) is delineated in AFDD 2, The Organization and Employment of Aerospace Power. This process was used as a baseline for developing a more in-depth understanding of COG visualization requirements. Note the lack of definition for how to determine the COG.

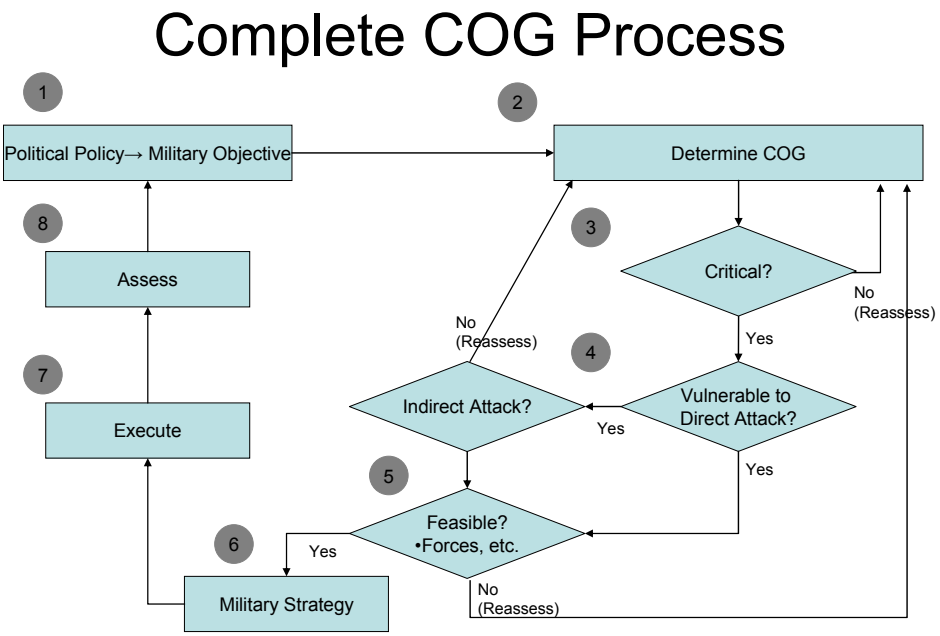
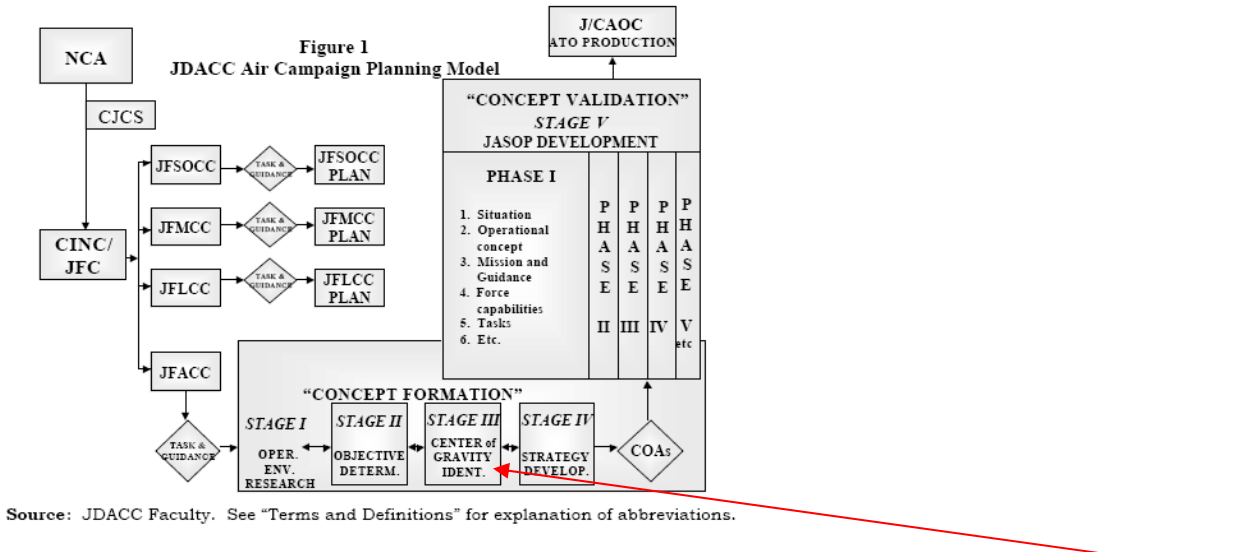


Figure 1. Baseline COG process. From AFDD 2. Organization and Employment of Aerospace Power (2000).

Current military doctrine identifies multiple planning models; Figure 2 shows the position of COG analysis within three representative process models. In each case, it falls within the middle of the planning process, between orientation to the operational environment (OE) and actual course of action (COA) development. It considers both adversarial capabilities and intent and is part of the conceptualization of the opportunities and limitations of the battlespace.



THE JOINT AIR ESTIMATE PROCESS: A SYNOPSIS	
PHASE I: MISSION ANALYSIS	Conduct initial Intelligence Preparation of the Battlespace (IPB). Phase I focuses on analyzing the joint force commander's mission and guidance to produce a joint air component mission statement and commander's intent.
PHASE II: SITUATION AND COURSE OF ACTION (COA) DEVELOPMENT	IPB is refined to include adversary COAs. Analyze adversary and friendly centers of gravity (COG). Develop multiple air COAs or one air COA with significant branches and sequels.
PHASE III: COA ANALYSIS	Friendly COAs are wargamed against adversary COAs.
PHASE IV: COA COMPARISON	Wargaming results are used to compare COAs against predetermined criteria.
PHASE V: COA SELECTION	Decision brief to joint force air component commander (JFACC) with COA recommendation. JFACC selects COA.
PHASE VI: JOINT AIR OPERATIONS PLAN DEVELOPMENT	Selected COA is developed into a joint air operations plan.

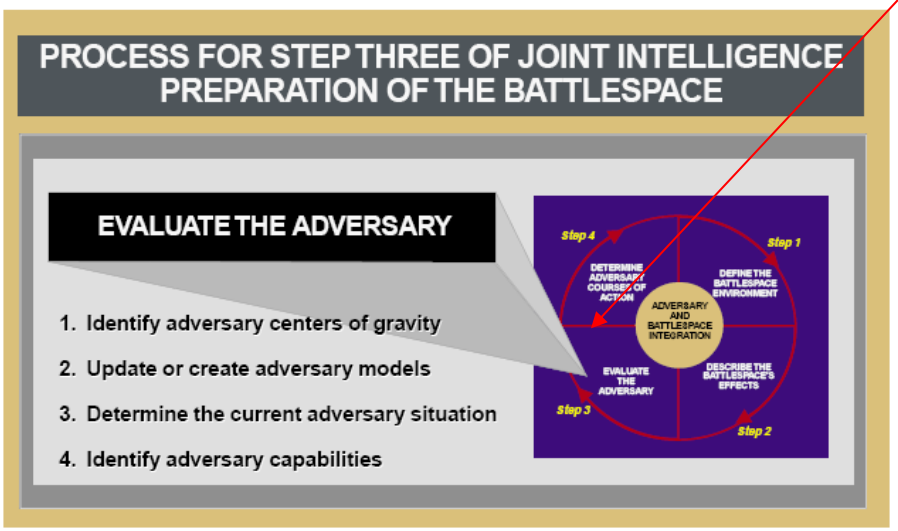


Figure 2. COG analysis within three planning concepts: The Air Campaign, Joint Air Estimate and Joint IPB processes. From the *Air Campaign Planning Handbook* (2000), the *Joint Air Estimate Handbook* (2005) and JP 2-0.1.3 *Tactics, Techniques & Procedures for Joint IPB* (2000).

This effort reviewed COGs within the context of joint, multi-service, and Air Force processes. The following documents were employed to understand current thinking with respect to joint (and Air Force) planning and COG analysis:

1. *Air Force Pamphlet (AFPAM) 14-118, Aerospace Intelligence Preparation of the Battlespace* (2001)
2. *Joint Publication (JP) 2-01.3 Joint Tactics, Techniques, and Procedures for Joint Intelligence Preparation of the Battlespace* (2000)
3. *JP 3-0, Joint Operations, Revised Second Draft* (2005) and *JP 3-0, Joint Operations* (2001)

4. *Air Force Doctrine Document (AFDD) 2, Operations and Organization*(2006) and AFDD 2, *Organization and Employment of Aerospace Power* (2000)
5. *Joint Air Estimate Planning Handbook, V. 5* (2005)
6. *Commander's Handbook for an Effects-Based Approach to Joint Operations* (2006)
7. *Supplement One to Commander's Handbook for an Effects-Based Approach to Joint Operations (Theory)* (2006)
8. *Supplement Two to Commander's Handbook for an Effects-Based Approach to Joint Operations (Operational Net Assessment)* (2006)
9. *Joint Forces Staff College (JFSC) Pub 1, Joint Staff Officers' Guide* (2000)
10. *Air Campaign Planning Handbook* (2000)

The earlier doctrine suggests nodal analysis employing Warden's *Strategic Ring* model—(Leadership, Organic Essentials, Infrastructure, Fielded Forces, and Population (Fadok, 1995). More recent works, especially effects-based literature, advocate an updated version, Barlow's *National Elements of Value (NEV)* model—Leadership, Industry, Armed Forces, Population, Transportation, Communications, Alliances; these categories represent commonalities in strategic thinking from Clausewitz through Warden (Barlow, 1992). Barlow's model provides additional sensitivity by allowing for differences in relative importance of nodes and relationships. Another model, perhaps less familiar to Air Force strategists, was developed at the Army War College Center for Strategic Leadership (AWC CSL). This model considers demographic, economic, geographic, historic, international, military, political and psychological factors as well as interests and political goals (Fowler, 2002). The CSL model has been used in an ongoing DARPA-sponsored project on artificial intelligence-aided COG analysis (Teguci, 2004).

The most recent planning doctrine represents an effects-based paradigm. The Joint Force Command's Draft *EBO Concept Primer* (2003) states,

> "Actions in a traditional plan are typically arranged around axes of advance or lines of march along linear sets of decisive points that lead to a defined center of gravity, whose destruction should result in the enemy's defeat" (p. 5).

The document goes on to stress that effects-based planning, in focusing on the desired end state is less linear and hierarchical; it emphasizes a dynamic, integrated *system of systems* (SoSA) approach that transcends *military* action to include *diplomatic*, *information*, and *economic* (DIME) solutions as well. SoSA models *entities* (including type and criticality), direct and indirect *relationships* (including type, strength and criticality), and direct and indirect *effects* for friendly, adversary, and non-aligned groups. The SoSA model promises a more complete and accurate assessment of the adversary, yielding a superior solution set.

While Warden's Rings and Barlow's NEV can be used in effects-based analysis, the *Commander's Handbook for an Effects-Based Approach to Joint Operations* (2006) employs a new battlespace model; OE elements are categories as Political, Military, Economic, Social, Infrastructure and Information (PMESII). Figure 3 shows a notional PMESII-based SoSA identifying COGs and opportunities to apply DIME actions.

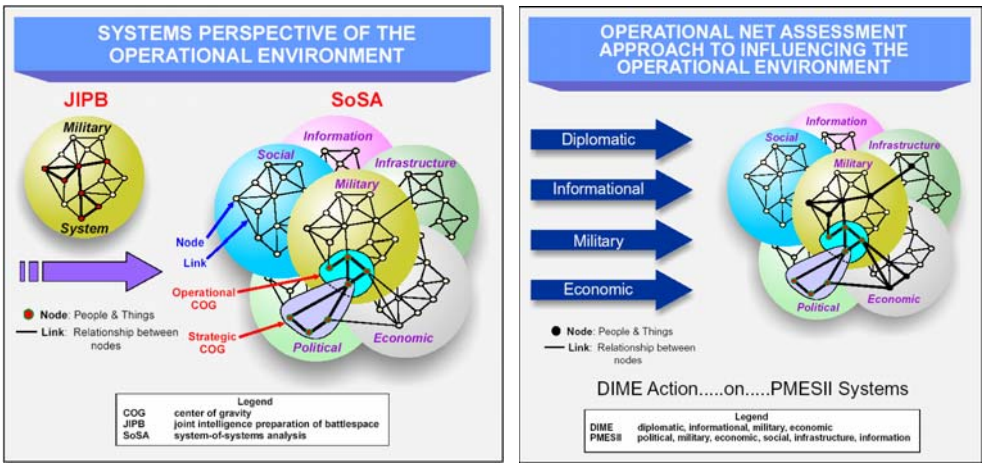


Figure 3. Nodal analysis from SoSA and ONA perspectives. From the *Commander's Handbook for an Effects-Based Approach to Joint Operations* and *Commander's Handbook…Supplement Two (Operational Net Assessment).*

The models above are simplified depictions. The *Commanders Handbook, Supplement One—Theory* (2006), clarifies the scope of a complete SoSA as envisioned in current EBO doctrine:

> "Unlike Clausewitzian thought, an effects-based approach extends beyond the enemy to the entire OE and its political, economic, social, ideological and other enabling systems that support the global, regional, or national grouping to be influenced. These systems may be trans-regional, transnational, or connected in functional and behavioral ways that are based on political, familial, commercial or cultural relationships**. The point is that an effects-based approach takes a systems perspective to *explain the behavior of the entire OE*: how it currently behaves and how it might behave under various influences and actions**." (p. 8, italics added for emphasis)

Supplement One to the Commander's Handbook for an Effects-Based Approach to Joint Operations—Theory (2006) also warns,

> "Depending on the effect desired, the importance of an element [within the analysis] will fluctuate. And consequently, if the ends are not understood at all echelons, the presumption will be that the classical (and often erroneous) centers of gravity—leadership, C2 [command and control], lines of communication, etc.—are most relevant to the success of the operation" (p. 9).

These observations illustrate the difficulty of achieving a comprehensive COG analysis—a multi-echelon, PMESII-based, comprehensive analysis is a lot of work. Although SoSA is clearly an effective method, is it a *cost-effective* method? It begs the question: Is it even possible—given time constraints and attentional limitations—in an OE? SoSA's promise of integrated, multi-echelon, multi-disciplinary, planning has great potential; exploring and addressing such SoSA issues provide the framework for the COG Viz effort.

COG Viz Literature Survey

The COG Viz literature survey reviewed documents from multiple disciplines, spanning Center of Gravity (COG) Theory and Application, Analysis and Modeling, Intelligence Preparation of the Battlespace (IPB), Operational Net Assessment (ONA), Effects-Based Operations (EBO),

and Planning Doctrine and encompassing descriptive and explanatory texts as well as apologetics and critiques. Sources included doctrinal joint and service publications, service-sponsored opinion papers, multi-service advanced school of military studies papers, military handbooks and manuals, instructional materials, articles from military professional journals, and think tank evaluative reports. The highlights of the literature surveys are captured in Table 1:

Table 1. Center of Gravity Issues Identified in the COG Viz Literature Survey.

Issue	**Sources**
The *Joint Air Estimate Planning* process places COG analysis within *Phase II: Situation And COA Development Tasks* (immediately following IPB refinement) after *Phase I: Mission Analysis* and prior to *Phase III: COA Analysis*	USAF. (2005). Joint *Air Estimate Planning Handbook, V. 5*. Maxwell AFB, AL: Warfare Studies Institute, College of Aerospace Doctrine, Research and Education. [Textbook for the Joint Air Operations Planning Course]
The Air IPB (AIPB) and Joint IPB (JIPB) cycles place COG analysis within *Step 3: Evaluate the Adversary* (immediately following *Step 2: Describe the Battlespace's Effects* and prior to *Step 4: Determine Adversary COA*)	JCS. (2000). JP *2-01.3, Joint Tactics, Techniques, and Procedures for Joint Intelligence Preparation of the Battlespace*. Washington, DC: Joint Chiefs of Staff USAF. (2001). AFPAM *14-118, Aerospace Intelligence Preparation of the Battlespace*. Langley AFB, VA: HQ ACC/INXX
The *Air Campaign Planning* process places COG analysis in *Stage III: Center of Gravity Identification* (immediately following *Stage I: Operational Environment Research* and *Stage III: Objective Determination*)	USAF. (2000). Air *Campaign Planning Handbook*. Maxwell, AFB, AL: Warfare Studies Institute, College of Aerospace Doctrine, Research, and Education.
There are multiple and conflicting definitions for the term COG (e.g., balance point vs. strength)	Echevarria, A. (2004). Center of Gravity Recommendations for Joint Doctrine. *Joint Force Quarterly*, *35*, 10-17. Johnson, M. (2001). Strange *Gravity: Toward a Unified Theory of Joint Warfighting*. Ft Leavenworth, KS: USA Command and General Staff College

There is confusion over *what* constitutes a COG (e.g., military power vs. will of the people; land forces vs. air forces)	Eikmeier, D. (2004). Center of Gravity Analysis. *Military Review*, July-August, 2-5. Anderson, W. (2004). Where *You Sit and Centers of Gravity: Bridging the Gap Between Army and Air Force*. Newport, RI: Naval War College
There is insufficient instruction on *how* to apply COG assessment models	Fowler, C. (2002). Center *of Gravity—Still Relevant After All These Years*. DTIC # ADA 401889. Carlisle Barracks, PA: US Army War College. Johnson, M. (2001). Strange *Gravity: Toward a Unified Theory of Joint Warfighting*. Ft Leavenworth, KS: USA Command and General Staff College
Services disagree over whether an adversary has single or multiple COGs	Fowler, C. (2002). Center *of Gravity—Still Relevant After All These Years*. DTIC # ADA 401889. Carlisle Barracks, PA: US Army War College.
There is disagreement over whether COGs can be found at multiple levels or whether a COG should pertain to the system as a whole.	Echevarria, A. (2004). Center of Gravity Recommendations for Joint Doctrine. *Joint Force Quarterly, 35,* 10-17
There are multiple methods for COGs assessment but no guidance on *whether* or *when* one is preferred over another	Johnson, M. (2001). Strange *Gravity: Toward a Unified Theory of Joint Warfighting*. Ft Leavenworth, KS: USA Command and General Staff College
Four models—Warden's *Five Strategic Rings*, Barlow's *National Elements of Value*, the CSL model, and SoSA's *PMESII* construct—require the analyst/planner to categorize the IPB	Warden, J. (1995). The Enemy as a System. *Air Power Journal*, Spring. Barlow, J. (1995). Strategic *Paralysis: An Airpower Theory for the Present*. Maxwell AFB, AL: Air University Press Fowler, C. (2002). *Center of Gravity Analysis—Still Relevant After All These Years*. Carlisle Barracks, PA: Army War College USAF. (2006). Commander's *Handbook for an Effects-Based Approach to Joint Operations*. Washington, DC: HQ USAF

COGs should be strategic only	Echevarria, A. (2004). Center of Gravity Recommendations for Joint Doctrine. *Joint Force Quarterly*, *35*, 10-17.
COGs can be strategic or operational	Eikmeier, D. (2004). Center of Gravity Analysis. *Military Review*, July-August, 2-5.
COGs can be strategic, operational, or tactical	Vego, M. (2000). Center of Gravity *Military Review*, March-April, 23-29 Strange, J. & Irons, R. (2004). Center of Gravity: What Clausewitz Really Meant. *Joint Force Quarterly*, *35*, 20-27.
COGs are dynamic, shifting over time as circumstances change	Strange, J. & Irons, R. (2004). Center of Gravity: What Clausewitz Really Meant. *Joint Force Quarterly*, *35*, 20-27.
COGs are of questionable value to military planning	Cancian, M. (1998) Centers of Gravity Are a Myth. *Naval Institute Proceedings Magazine*, September.

The information acquired during the literature survey was used to guide the tools and methods review and to develop the elicitation plan. Specific insights were also incorporated into the baseline requirements. As is evident from the citations in Table 1, the literature review is rife with contradictions, admissions of confusion, and laments for lack of COG identification methodology—although the literature search did turn up one comprehensive structured method developed by the CSL (Giles & Galvin, 1996). The *Critical Capabilities-Critical Requirements-Critical Vulnerabilities (CC-CR-CV)* method, developed by Dr. Joseph Strange (aka the Strange model) and taught at all military schools, is a pragmatic and easily understood way to assess COGs. However, it appears to assume that the analyst/planner can correctly determine the COGs in the first place (Strange & Irons, 2004). History shows that our efforts have not always been accurate (Cancian, 1998) and the inclusion of non-state actors as adversaries, necessitated by the Global War on Terror (GWOT), adds both ambiguity and complexity to the task (Anderson, 2004; Echevarria, 2004; Strange & Irons, 2004). The implication for a COG Visualization tool is that flexibility is required to provide visualizations that support both more and less structured approaches to COG identification for both state and non-state adversaries.

Each of the three most-cited categorical models (Warden's Rings, Barlow's NEV, PMESII) has its proponents—and its detractors. Although services vary in their interpretation of how to implement Dr. Joseph Strange's concepts, all of the services teach the Strange model for COG decomposition. Thus, the guidance derived from the literature search determined that, in order to be flexible enough for joint use and to serve the maximum range of users, the COG visualization tool should accommodate different schools of thought. Rather than supporting a single or several favored models, the tool should support user-defined models. It should also feature a taxonomic structure that would recognize conceptual relationships across models. These decisions, which sidestepped choosing among factions, became baseline requirements for the COG Viz system.

COG Tools & Methods

The search for tools used for COG analysis did not turn up many systems. The review initially focused on Air Force and DoD efforts but expanded to incorporate relevant tool and methods efforts in other fields, most notably biology. The review included a gap analysis that led to further identification of COG Viz requirements.

1. Air Operations Center (AOC) planning tools, the *Theater Battle Management Core Systems* (TBMCS) architecture and *Information Warfare Planning Capability* (IWPC) 4.2 include tools for mission analysis, course of action (COA) development, and COA evaluation. COG analysis is supported by AFRL/IF's Strategy Development Tool (SDT), which includes the COG Articulator component for modeling COGs (Caroli, Fayette, Koziarz & Stedman, 2004). COG Articulator both facilitates construction of "light-weight" COG models that characterize adversarial capabilities and models the effect of proposed "interventions" on end state attainment. The causal chains for selected plans of action can be exported from the COG Articulator into the Causal Analysis Tool (CAT) for probability assessment or directly into the SDT plan editor. SDT Endstate integrates Order of Battle (OB) information, COG models, and specified desired end states to produce EBO-focused strike target lists. Figure 4 shows the anticipated interaction of SDT components (James & Daniel, 2005).

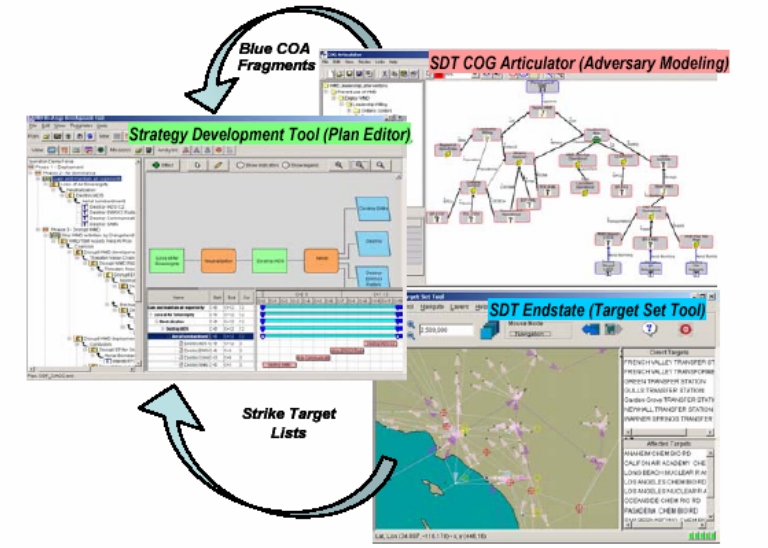


Figure 4. Strategy Development Tool (from Caroli, Fayette, Koziarz & Stedman, 2004).

SDT is developed as a proposed AOC planning component with the TBMCS structure; as such, it interacts with IWPC. Planning for IWPC's successor, *Information Operations Planning Capability-Experimental* version (IOPC-X) has just begun this year. Lessons learned from IOPC-X will be incorporated into the joint tool, IOPC-J, which is not expected to begin development until 2008. To date, no firm decisions have been made about which tools will transition from IWPC to IOPC. As a component of the Commander's Predictive Environment (CPE) program, COG Viz project will feed development of analytical capabilities in these AOC planning systems.

2. The *Sensor Harvest* program, developed by the Air Force Information Warfare Center (AFIWC), is a Command and Control Warfare (C2W) planning tool with Information Warfare (IW) capabilities (Waterman, 2004). It supports both strategic and operational planning and is intended for use in both deliberate and crisis action planning scenarios (Air Intelligence Agency, 1997). The Sensor Harvest office uses nodal analysis to identify centers of gravity for target countries, terrorist groups, and non-governmental organizations. Each center of gravity is decomposed into critical nodes (e.g., leadership, military, infrastructure, facilities, economics, politics, and culture). The analyses support development of information warfare target files which include assessments of target node criticality, vulnerability, and feasibility in the areas of psychological operations, deception, physical destruction, electronic warfare and operation

security. Sensor Harvest products are available on SIPRNET. The technologies and methods used in Sensor Harvest were not available for inclusion in this report.

3. George Mason University, AFRL/IF, and the Army War College Center for Strategic Leadership (CSL) collaborated on a Defense Advanced Research Projects Agency (DARPA) project—Disciple Rapid Knowledge Formation and Reasoning (RKF), whose first test case involved COG identification. An artificial intelligence research project, Disciple RKF employs elicitation formats, ontologies, rule sets, and intelligent agents (Tecuci, 2004). Its artificial intelligence research objective was the development of knowledge bases and agents by subject matter experts, with minimal assistance from knowledge engineers. A concurrent military strategy research objective was the development of a systematic approach to center of gravity determination. Customized versions of the Disciple-RKF/COG agent have been used in the Army War College's "Case Studies in Center of Gravity Analysis" course, assisting students in COG determination since 2001. In the 2004 experiment, intelligent agents, trained by teams of experts, successfully completed 98.15 percent of the reasoning steps required to correctly assess adversary critical capabilities in a notional war scenario. Future plans include enhancing Natural Language Processing (NLP) capabilities, improved knowledge acquisition techniques, and meta-rule formation to capture rationales for problem-solving method selection.

4. *Automated Assistance with Intelligence Preparation of the Battlespace (A2IPB)*, an AFRL/IF program, provides a method to collect and document analytical elements and to capture analytical insights. The A2IPB system provides some support to COG analysis: the *A2IPB Version 3.2.0 Draft Student Workbook* (Zeltech, 2004), explains the importance of COG analysis within its discussion of the A2IPB and the Joint IPB (JIPB) process and its online Help system directs the user to its Electronic Notebook to enter COGs (*A2IPB Online Help and Functional Guidance—A2IPB version 3.2.0*). However, the *Workbook* offers no examples of COG identification, and in its exercises, prompts students to model the adversary's tactics and to determine high value targets (HVTs) based on criticality to predicted adversarial COAs. The Electronic Notebook is the user's information repository; the online Help system explains how to enter identified COGs rather than how to establish COG identification. To identify COGs the user is simply directed to review the information obtained in JIPB cycle Step 1–Define the

Battlespace Environment and Step 2–Describe the Battlespace Effects. A2IPB publishable products include Named Areas of Interest (NAIs), Target Areas of Interest (TAIs), Units, Individuals, Infrastructure Areas (IAs), COAs, Lines of Communication (LOCs), Individuals, NAI Matrices, Target Value Matrices, LOC Matrices, and COA Matrices—but not COGs.

A2IPB link analysis capability is provided by the *Web-Enabled Timeline Analysis System (WebTAS)*, which also supports timelines, map displays, graphs, and tables. WebTAS pulls information from the A2IPB database, and through A2IPB's integration with *Broadsword*, supports importation of data from multiple data sources. However, although it explains how to run a Broadsword queries, A2IPB literature does not list capabilities to autofill data fields or to automated query generation. Nor does it appear to employ NLP or support taxonomy-based automated network creation. Information the analyst/planner deems relevant is pasted into Electronic Notebook; data critical to product generation is manually entered or copied and pasted into system data fields. Network models must be built manually. While A2IPB displays individual elements of information in appropriate formats (e.g., maps, imagery, tables, etc.), it does not appear to support the large-scale, multi-echelon network analysis required for accurate, defensible COG identification.

5. The Australian Government's Department of Defence Science and Technology Organisation (DSTO) sponsors the Centre of Gravity Network Effects Tool (COGNET). COGNET models decompose and prioritize COG elements, organizing them hierarchically to show associated critical and lower level capabilities. COGNET represents COGs as Bayesian nets to support probabilistic cause and effect assessments for proposed interventions targeted anywhere within the hierarchical COG structure (Falzon & Priest, 2004).

The tools and methods review suggests a common theme. JFCOM's *Commander's Handbook for an Effects-Based Approach to Joint Operations* (2006) suggests SoSA-based ONA as an analytical method. Richard Bullock (2002), while Chief of Theater Operations Modeling at the Air Force Studies and Analyses Agency, and Alexander Levis (2004), former Chief Scientist of the Air Force, proposed modeling COGs with influence nets—another name for Bayesian inference nets. As noted above, AFRL/IF (Evans, Jones, Pioch, Prendergast & White, 2004) and

Australia's DSTO (Falzon & Priest, 2004) employ Bayesian nets to assess causal chains in COG analysis. Network analysis is a critical technique in IPB analysis. In the intelligence community, non-probabilistic social/communications network analyses are accomplished using such links and nodes tools as *Analyst Notebook* and *TELSCOPE* (Henry, 2004; Wood, 2003). The common theme in the newest and most capable COG analysis tools is network analysis.

However, Lt Commander Michael Hannan (USN) sounds a warning note in his 2005 paper on ONA. He cites Carnegie Mellon University's Kathleen Carley, who, in her work for the Office of Naval Research (ONR), found that "the tools available now cannot handle both [conceptual and computational] types of information at a fidelity required by ONA". While network modeling capabilities lag requirements, rapid navigation through and comprehension of complex, multi-level network presentations is difficult as well (Mukherjea, Foley & Hudson, 1995). Efforts to improve navigation involve network overviews, rule-based node filtering, drag-and-drop network manipulation and manipulation of 3-D in 2-D representations (e.g., Klein & Reiterer, 2005; Quang & Mao, 2005; Thinkmap a & b, 2005).

Visualization of the OE Common Operational Picture (COP), a goal delineated in *Joint Vision 2020*, is the focus of multiple DoD projects (e.g., programs by Analytical Graphics, Inc., ESRI, General Dynamics, Microsoft, SRA International Inc., etc.). Yet most of the efforts to produce a COP are limited to attempts to provide real-time updates to fused geospatial and other (e.g., event, asset, demographic, etc.) data sets (ESRI Developer's Summit, 2006). The visualizations that illustrate how COGs impact the operational environment are typically presented either in matrices or in nodal displays that are disconnected from geospatial renderings, making cognitive aiding through enhanced visualization an incompletely achieved objective. Work at Iowa State in navigating complex metabolic network provides one potential solution—3-D immersion moderated by a 3-D in 2-D navigation display (Dickerson, Yang, Blom, Reinot, Lie, Cruz-Neira, & Wurtele, 2004). The user moves through the virtual network to investigate its contents but maintains an overview, as well as navigational control, through a separate, handheld version of the display. The same kind of filtering algorithms that support navigation can also break the network into comprehensible chunks.

In summary, COG visualization requirements include interaction with TBMCS, large-scale multi-echelon influence network displays, probabilistic causal analysis capabilities, data fusion visualizations that link influence network data to geospatial and temporal data, filtering capabilities, rapid navigation techniques, and both god's eye and immersive perspective.

Warfighter Analysis Workshop Elicitations

Elicitations for the COG Viz program were conducted both at the preparatory conference for the Warfighter Analysis Workshop (pre-WAW) and at SRA. Comments were obtained from a range of planners, whose experience base included both planning and assessment. Interviews were conducted using Cognitive Task Analysis procedures, including the Critical Decision Method (CDM) interview technique developed by Klein Associates, (Klein, Calderwood, & MacGregor, 1989). An elicitation probe document was developed to guide elicitations. Interview results were analyzed for information requirements and decision points using event sequence modeling and decision requirements tables (Pyy & Andersson, 1997).

Air Force input was represented by 2 active duty Lieutenant Colonels, 2 active duty majors, 2 active duty Lieutenants and a DoD employee. A separate intensive 2-day interview was conducted at SRA International, Inc., in order to capture the planning expertise of a MAJCOM planner. The notes from these interviews are found in Appendix A. The interview notes and derived requirements were reviewed by a retired Lieutenant Colonel with operational expertise to ensure system requirements met operational needs. Insights derived from the elicitations are found in Table 2.

Table 2. Elicitation Insights.

Observation	**Source**
COG Analysis	
System needs to support integrating Blue COG analysis and Red COG analysis for integrated planning	WAW Interview Notes
System needs to take COG analysis to target systems analysis and to weapon/target pairing	WAW Interview Notes

Users need more training in COG analysis and COG analysis tools, techniques and methods	WAW Interview Notes
System needs to handle both concrete and conceptual COGs (e.g., physical capabilities vs. moral/morale)	WAW Interview Notes
System needs to lighten COG analysis workload/shorten COG analysis timeline	WAW Interview Notes
Which COG models are used, and whether they are used at all, is dependent upon the preferences of COCOM OR JFACC commander (depending upon whether the planning situation is during peace or war)	WAW Interview Notes
System needs to accommodate multiple modeling methods	WAW Interview Notes
System should support identification of 1) Known Knowns, 2) Known Unknowns, and 3) Unknown Unknowns	MAJCOM Notes
System should support user-developed models (e.g., people, stuff, money)	
Planning Integration	WAW Interview Notes
System needs to support defense of plan elements—planning rationale	WAW Interview Notes
System needs to support planning beyond just military solutions—DIME vs. M only	WAW Interview Notes
System needs to support anticipated damage and reconstitution planning associated with specific targeting schemes	WAW Interview Notes
System should support planning based on tasks listed in mission analysis brief (e.g., Gain Air Superiority, Conduct Close Air Support, Support CFLCC)	MAJCOM Notes
System should support integrating plan phasing and scheduling into visualizations	MAJCOM Notes
System should support both deliberate and crisis action planning timelines	MAJCOM Notes
Visualization	
System needs to support lines of effect visualization	WAW Interview Notes
System needs to be able to scale visualization outward (overview and inward (focused, detailed view)	WAW Interview Notes
System should support geospatial views	MAJCOM Notes
System should support visualizing dynamic nature of battlespace and how desired effects morph over time	MAJCOM Notes
System should support visualizing PMESII or other model elements	MAJCOM Notes

that will impact plan success	
System should support visualizing desired end state vs. current state	MAJCOM Notes
System should support toggling multiple layers over foundation visualization	MAJCOM Notes
System should support COA Sketch project or include COA Sketch capability	MAJCOM Notes
System should work with geospatial coordinates and various standardized geospatial product levels of detail (e.g., 1:2,000,000 vs. 1:1,000,000 vs. 1:50,000)	MAJCOM Notes
System should provide "thinking aids" and not just documentation of thought-out plans	MAJCOM Notes
<u>Generating Items</u>	
System needs to support RFI generation	WAW Interview Notes
System needs to support generation of PowerPoint briefings	WAW Interview Notes
<u>Making Assessments</u>	
System needs to make assessment easier for Operations Assessment Team—not harder	WAW Interview Notes
Need to be able to assess success as soon possible in order to replan or divert assets	WAW Interview Notes
System should support ongoing mission effects assessments	MAJCOM Notes
System should support prioritization and weight of effort assessments	MAJCOM Notes
System should support Value-Focused Thinking assessments (e.g., use tactical objective as the value model; see notes for discussion))	MAJCOM Notes
<u>Coordination</u>	
Strategy Plans Division tools need to support coordination and information sharing with Combat Plans and Intelligence, Surveillance, and Reconnaissance Divisions.	WAW Interview Notes
System needs to support multiple analysts working a problem	WAW Interview Notes
System should pull in and work with Order of Battle information, target lists, restricted target lists, no-strike lists, prioritized effects lists, rules of engagement/laws of armed combat, etc.	MAJCOM Notes
System should support the use of MILSTD 2525 symbology for ease in communication joint service	MAJCOM Notes
System should support identification and tracking of Key Operations Objectives List	MAJCOM Notes

Computational Issues	
System should be prepared to cope with large task to objective mapping (e.g., JEFX 2004 had some 12 operational objectives broken into some 1700 tactical tasks)	MAJCOM Notes
System should aid filtering of available DMPIs [Designated Mean Point of Impact>targets] by desired effects and maximum effectiveness (e.g., JWAC shows possible 10,000 targets vs. only need to hit 4,000 targets)	MAJCOM Notes

Baseline Requirements Development

The doctrine and literature surveys, tool and methods review, and initial elicitations formed the groundwork for requirements development. The first analysis performed was a sensemaking attempt to relate the COG identification processes described in the JAEP and the AIPB and JIPB documents. The result was a concept map that identified and related the requisite tasks preliminary to COA development (see Figure 5).

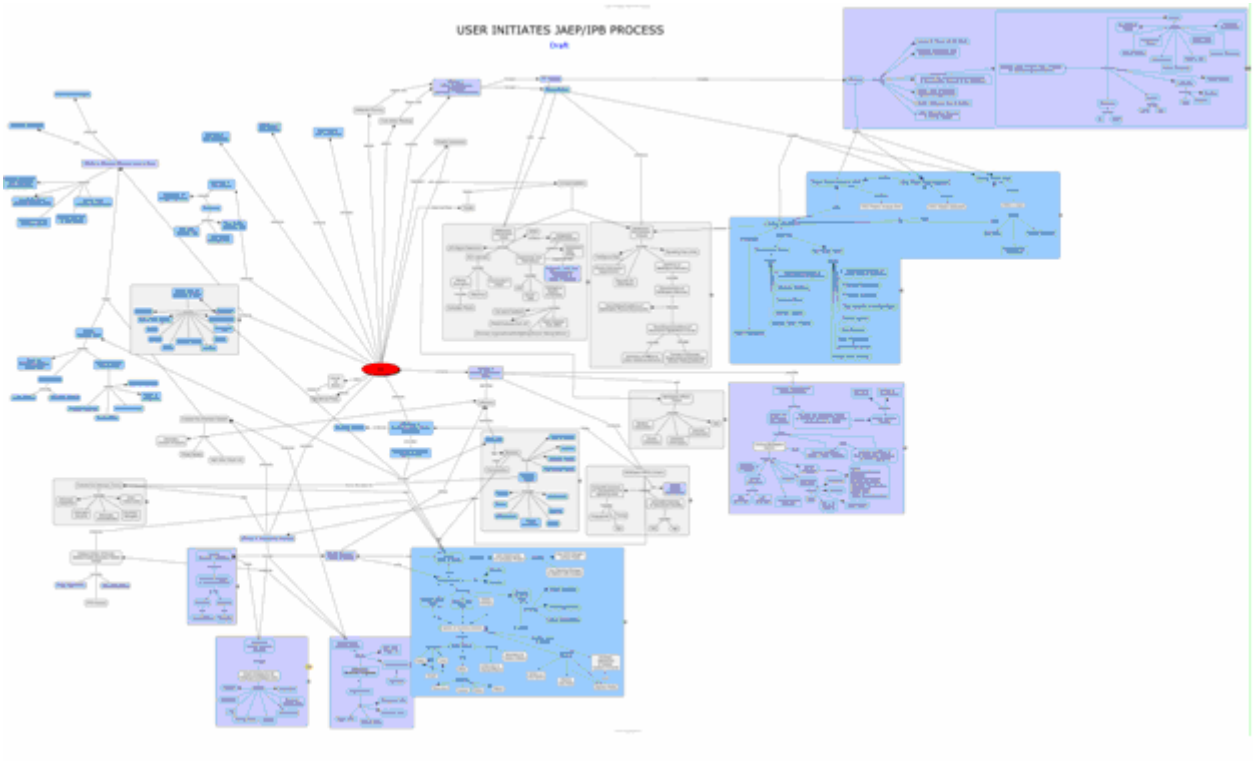


Figure 5. Concept map relating JAEP, AIPB and JIPB doctrinal processes prior to COA development.

The information derived from this analysis supported the elicitation plan and baseline requirements development, including a tentative use case for COG analysis. Figure 6 maps the elements of the process described by the MAJCOM planner. Figure 7 integrates the COG Analysis requirements from multiple sources. The improved understanding of COG requirements will drive future elicitations for the VOEUR project.

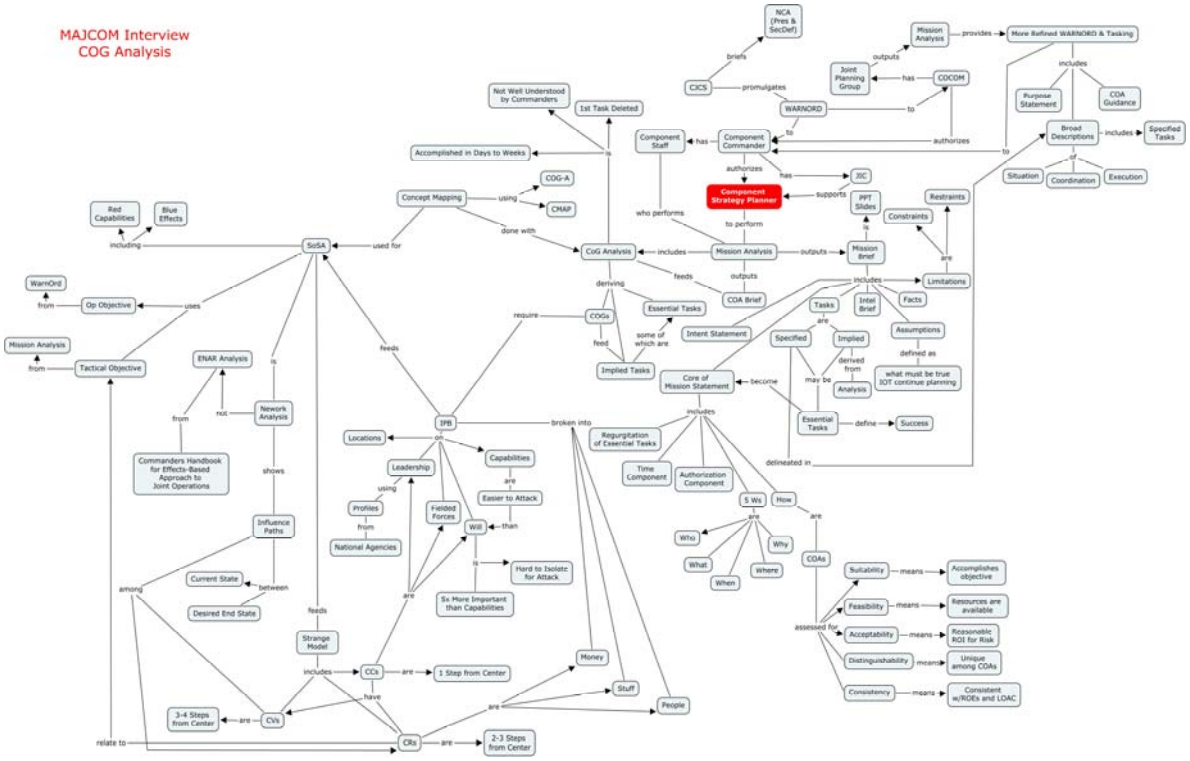


Figure 6. Understanding of COG process gained from MAJCOM planner interview.

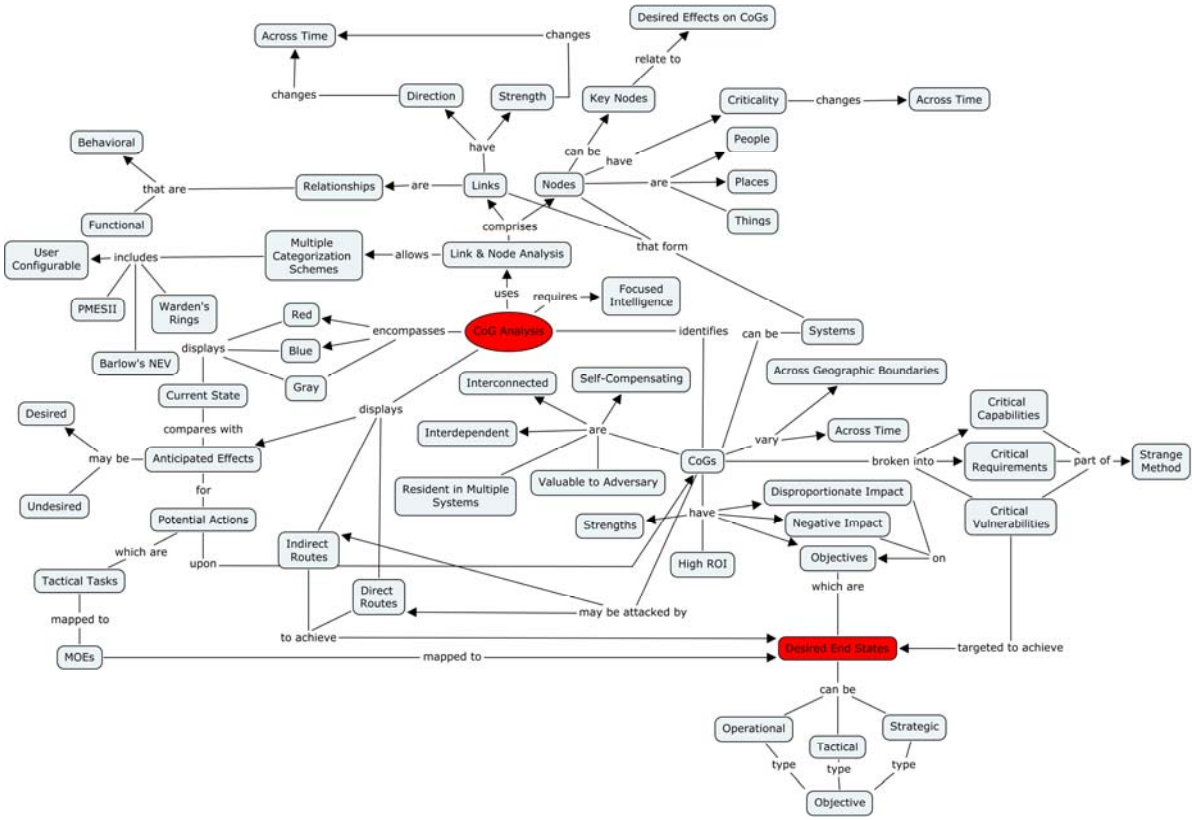


Figure 7. COG Analysis Requirements

Although there are a number of requirements that are identified from the elicitations, not all of them are directly related to visualization needs. Further, the project team is acutely aware that it has only collected information from a limit set of SMEs. Therefore, the end product of the COG Viz effort is limited to a baseline set of requirements and a baseline feature set. These products are being used to plan future elicitations under the VOEUR project and to guide VOEUR concept visualizations for presentation to potential users. Table 3 shows some of the features derived from the requirements analysis (for additional information see Appendix B).

Table 3. Proposed baseline COG Viz feature set.

Feature Set Name	Description	Process Goal
Nodes	Nodes (objects) can be created with differing properties and viewed in 3D space	Capturing of physical and conceptual elements for visual thinking
Node characteristics	Nodes can be coded by:	Capturing of physical and

	Color (Image) Size Shape	conceptual elements for visual thinking
Links	Nodes can be linked (related). This is viewed with lines within the 3D space. These lines can be differing color and width.	• Understand relationships between elements • Understand system complexity • Understand relationships between systems • Understand related requirements between elements • Understand system complexity • Understand relationships between systems
Link Characteristics	Link lines can be differing widths	• Show strengths of relationships in both directions • How hard it is to break the relationship
Categorization	Nodes can be laid out (placed) within the 3D space on differing planes in the 3d space based on any Node property.	• Grouping or categorization of a set of relationships that exist only upon an individual working in the given role? Indicates that each role has its own system to consider. • Grouping of data by user defined purpose
Filtering	Nodes can be filtered form the 3d view based on any node property or any relationship property	• Grouping or categorization of a set of relationships that exist only upon an individual working in the given role? Indicates that each role has its own system to consider. • Grouping of data by user defined purpose
Annotations	Flags or notes or	

	annotations can be placed onto any node and are displayed in the 3d space	
First person View	The 3d space can be viewed in a first person view	
Third person view	The 3d space can be viewed in third person view with an avatar on screen representing current location within 3D space.	
Properties sub view	The properties sub view will display all node properties of the node that is selected in the 3d space	
Past Flight path	A breadcrumb like trail can be turned on within the 3D space to give user where they've been information.	
Importance	Importance can be represented by node shape, size, color, and spatial placement.	• Establish differential importance to assist in narrowing the focus to the key relationships in the dataset
Node Decomposition	One can "walk into" a system represented by a node and see what is in that system	•
Interactive Updates	• Event driven update to nodes relationships and their attributes based on assessment of the operational environment • Show history of at least prior state • Allow user to set snapshots of	• Adjustment of evaluation due to changes in Centers of Gravity and other key nodes due to actions taken and reactions of the adversary

	state at their discretion • Track of state changes over time	
		Establish quantified importance based on analysis of the interdependencies (subordinate, superior, peer)
		Establish differential importance to assist in narrowing the focus to the key elements in the dataset
		• Matching to Laws of Armed conflict and other social moral restrictions in order to guide approved actions? (Allow for interpretation of potential allowed targets otherwise restricted but due to associations to approved target type are now legal) • Matching to DIME actions that can be applied?

Conclusions

The COG Viz project successfully elicited and documented requirements, concerns, issues, and desired features for both COG analysis and for OE analysis with respect to strategic and operational planning. Sources included doctrine, papers for advanced military studies, professional military journal articles, as well as elicitations with potential users. Primary requirements include flexible, user-defined modeling methods, integration of massive amounts of data, user-defined data filtering, inferencing capabilities, multiple network analysis methods (e.g., social nets, influence nets, ecological nets), integrated operational environment visualizations, detailed and synoptic views, easy navigation, and planning aids that extend beyond current plan documentation capabilities into cognitive aiding and analytical support. The current VOEUR project continues to elicit, document, and assess these requirements and will develop prototype demonstrations for evaluation by the user community.

Acronym List

A2IPB	Automated Assistance with Intelligence Preparation of the Battlespace
AFDD	Air Force Doctrine Document
AFIWC	Air Force Information Warfare Center
AFPAM	Air Force Pamphlet
AFRL/HE	Air Force Research Laboratory Human Effectiveness Directorate
AFRL/IF	Air Force Research Laboratory /Information Directorate
AIA	Air Intelligence Agency
AIPB	Air Intelligence Preparation of the Battlespace
AOC	Air Operations Center
AWC	Army War College
C2	Command and Control
CAT	Causal Analysis Tool
CC	Critical Capability
CDA4PBA	Commander's Decision Aid for Predictive Battlespace Awareness
COA	Course of Action
COG	Center of Gravity
COG Viz	Center of Gravity Visualization
COGNET	Center of Gravity Network Effects Tool
COP	Common Operational Picture
CPE	Commander's Predictive Environment
CR	Critical Requirement
CSL	Center for Strategic Leadership
DIME	Diplomatic, Information, Military, Economic
CV	Critical Vulnerability
DoD	Department of Defense
DSTO	DSTO
EBO	Effects-based Operations
HVT	High Value Target
IA	Infrastructure Area
IOPC	Information Operations Planning Capability
IOPC-J	Information Operations Planning Capability-Joint
IOPC-X	Information Operations Planning Capability-Experimental
IPB	Intelligence Preparation of the Battlespace
IW	Information Warfare
IWPC	Information Warfare Planning Capability
JCS	Joint Chiefs of Staff
JFCOM	Joint Force Command
JIPB	Joint Intelligence Preparation of the Battlespace
JP	Joint Publication
LOC	Lines of Communication
MAJCOM	Major Command
NAI	Named Area of Interest

NEV	National Elements of Value
OB	Order of Battle
OE	Operational Environment
ONA	Operational Net Assessment
ONR	Office of Naval Research
PMESII	Political, Military, Economic, Social, Infrastructure and Information
SDT	Strategy Development Tool
SIPRNET	Secret Internet Protocol Router Network
SoSA	System of Systems Analysis
SRA	SRA, International
TAI	Target Area of Interest
TBMCS	Theater Battle Management Core System
USA	United States Army
USAF	United States Air Force
USN	United States Navy
VOEUR	Visualization for Operational Understanding and Response
WAW	Warfighter Analysis Workshop
WebTAS	Web-Enabled Time Analysis System

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Appendix A. Interview Notes

PRE-WAW Interview Notes

Notes from Cog Viz session 2, Conference Room A, April 5, 2006 1415

Government sponsor provided the high level briefing that included only 2 slides. She handed it over to moderator lead for discussion.

Within COA development, we write an operational or tactical objective directed at the adversary, directed at their COG. Alternative COAs really depend on how much we focus on that COG.

Warden's model is the most prevalent. Is that what we're going to use? I've never heard of any of the others. You look at the rings and you hand them out to different people. Divide them by elements in the model (leadership, economics, etc.) You then decide what are the COGs for the target area.

USMC and Army are far more rigid within the MDMP than we are.

Army Reg. 5.0 is where MDMP can be found.

Air Force uses their own process, which is much like MDMP. We think we can't issue Orders, but we do. We think we only issue plans.

They took tours of various organizations around DC so they could identify experts for various world wide areas. They brought many of them down to where they are to talk about their areas of expertise.

Dr. Kevin Pollack, Brookings Institute, is one of those experts.

It is typically ad hoc to figure out where you get your data.

In exercises they try to go by doctrine, which is not what they do in real life. In real life, the personality of the leaders guides how things are done.

Where do you get info?
- Primary sources:
  - Secret Service
  - State Department

You go wherever you can to get the information you need.

Another guy:
I found lots of information digging through target folders.

How did you access the target folders?
SIPRNET back to CENTCOM.

Guys at 32nd AOG used those folders also.

I created my own database for the primary targets.

Included various options, geographic data, targeting options. He plotted them on maps using FalconView on ITS.

"Remember, that's the way "named colleague" did it. It's so personality dependent."

The mindset will be different based on mission type. I did narcotics interdiction. We looked for information to give to the Columbians so that they can handle the situation. My entire context is different because my operation is non-kinetic. I am in support of SOF missions.

A lot of units use the CIA world fact book. They break it down into the standard categories. That gives the intel analysts a starting point to go and find out more about . . . the government, for example. They might look at literacy rate to tailor the pamphlets to that level.

As an intel group, the fact book gives us our generalization. We then use that to go get the nitty gritty.

Trying to identify critical capabilities and vulnerabilities, I use a system of systems approach.

We need to identify what they rely on for various things, like power or heat.

What is the education level? You need a way to document these areas so that if they become important, we see them. A checklist style format might work.

Once you identify your COGs, and you predict something based on an event and they do something different, you must reanalyze your COGs.

Difference between COAs and branches and sequels.

I have alternative potential plans, then analyze them against the enemy, we make a recommendation. He then chooses his preferred COA. They are blessed by the commander and we'll expand that and make that the center of the operational plan for the JAOC. COAs can usually be preceded by the word alternative. Once we choose one, that's the plan. When building one, we make assumptions. These assumptions become the focal points of the plan. We generate alternatives for each assumption.

We then talk about what each COA is trying to do. For example, this COA will attack their leadership and we think this will result in this change. Based on that change, we will then do this COA.

Are you always focused on the end state?
Yes.

Do you need to make sure that a state doesn't change, and therefore you need COGs to know when the situation might change and you want to change it back to where it was?

Operational COGs are different by mission phase. That is true for both Red and Blue forces.

"I don't find it useful to have tactical COGs. We need to use the COGs to help us write COAs, effects, and objectives."

A COG is not an Achilles heel. The vulnerability in the strength is what you can attack. We try to protect our own vulnerabilities. We look for vulnerabilities to exploit to defeat their forces or we find vulnerabilities in leadership. How do we prosecute those vulnerabilities.

You need to continually update the things that change that might impact the success of your attack on those vulnerabilities.

Dr. Strange teaches at CGSC at Quantico.

When we talked about the regime in Iraq, there's the "guy" and his inner circle. But you had the guy just outside of that who was really pulling all the strings.

If you do enough research, the answer becomes obvious.

The M is going to break out into 4 areas:

Air
Land
Sea
SOF

Warden's is what they are teaching. But, we need to dynamically react so people can update their buckets.

They talk a lot about Warden and then they talk about flexibility. "don't go in with such a concrete approach that you can't see the forest from the trees."

Warden was a success after Vietnam. It is well written

It is important to pick a methodology and stick with it.

How do we filter the data?
You are automatically limited.
If we are covering the P. We are limited as the Air Force. There's the military P, and within that is what the Air Force can do.

There are parts of the P problem that are simply not my job, but I must pay attention to some of those other elements.

Do you only focus on the M?

No. Out of the DIME, we are really only the M. That is all we have to bear. Application of the DIME means that we are the M.

The matrix is: what do I have to bear in theater, matrixed with PMESII. In almost any plan, you can get to a certain place in lots of different ways.

How do I show you all of this?

Is it strict nodal analysis?

Show nodes with most things going to it?

Show nodes with the most critical connections?

How do I make a template to show COG (what's that checklist)?

A: It depends. Which makes the most sense for certain situations. Which is the easiest to understand? Is it personality based?

Q: Should I give the operator all models?

A: That would confuse him. He will pick whatever the computer tells him.

I have a problem. There is no cookie cutter solution for this. It is too situationally dependent. Korea is different than Columbia which is different than India.

A drop-down menu of Warden, Strange, Barlow, PMESII. If you give the operator this option, will they know which to use? We can provide guidance regarding which to use.

"I will never get on a computer to get this going. I grab creative people, get together, and brainstorm. To be constrained by a computer program or tool is not conducive to what I try to do at the beginning."

How do you do your homework before those sessions?

It depends on the situation. I cannot give you a model that will apply to every situation.

These models are ways to filter, they structure your work into workable pieces.

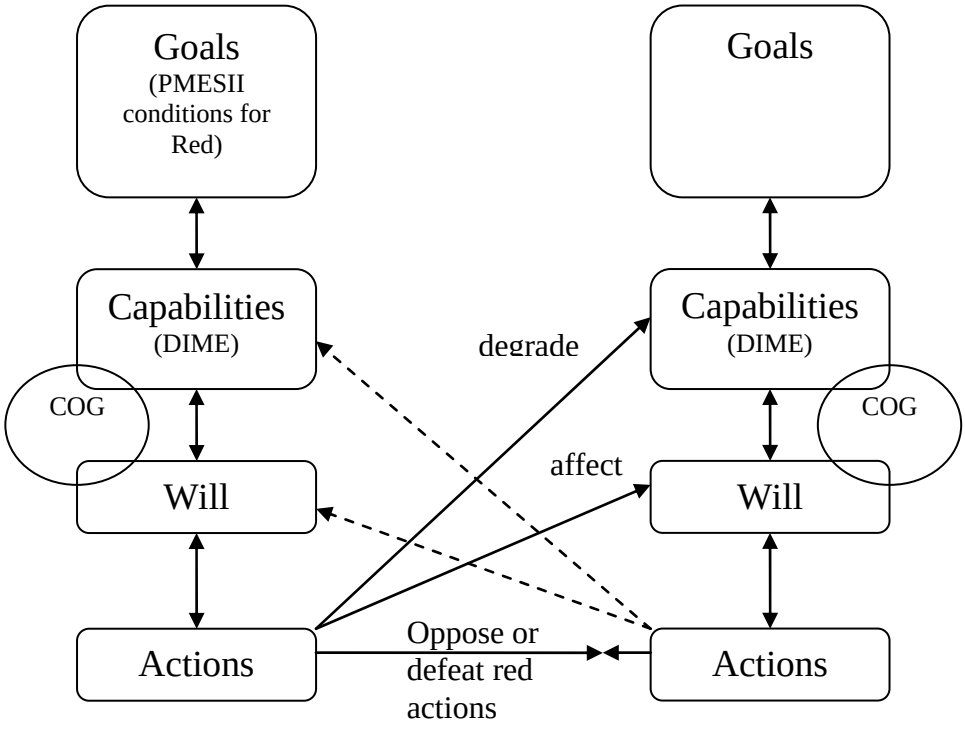
For me to accomplish my mission, I need to identify my end goal and work backwards. Example, food following a tsunami. How do I get enough food? How do I protect these people? How do I protect them from neighbors? What do their neighbors have that could threaten them? What might I do about those?

I could have something really important that has only one relationship. That could be the most important node and it has only one pathway.

I can imagine myself putting these pieces together, but what's the point? We need to maintain focus on the end state. If the answer bubbles to the top, why waste time filling out a model?

[A SME put up the following graphic.]

Drawing



When dealing with real world situations, you must consider this a two sided problem. Our actions are usually to degrade his capabilities, affect his will, oppose his actions. They are trying to do the same thing to us. Within this, the COGs must be identified that allow us to have the impact we want. COGs are described as source of strength and the will to use that power. COGs lie in an overlap between capabilities and will. Where does PMESII lie? This might lie in the goals of each side.

If I'm trying to analyze a COG, he's going to use his actions to oppose me (information, economic, diplomatic, military, etc.).

PMESII conditions do not necessarily map to the capabilities, will, and actions of the enemy in a direct fashion.

Moderator: maybe we start to map capabilities and will to COGs. This could provide an initial starting point.

I like Wing Commander Red Thompson's lines of effect. That works for me. It provides a roadmap for where you might go.

Notes from Cog Viz session 5, Conference Room B April 5, 2006 1415 (Interviewer 1)

COG – Understand the Battlespace, but no consensus on how to do COG analysis

COGs typically come down from the JFC level (1 person's statement reflecting COGs as handed down from JFC, with no input; some others had bi-directional input experience)

Narrowing the battlespace is just Strategy-to-Task

Ex: Hurricane season is a parallel
- Multiple models
- Likes Warden's simplicity, but Warden doesn't provide much beyond that
- Barlow shows COG as living, reactive enemy. Interactive, but hard to do
  - What enemy exists at the end of the day
  - Implies necessity to revisit and update COG analysis with information changes/augmentations
- Strange – breaks down into actionable chunks (however, starts by COG assuming a COG has been identified)

Wants to see all three, because each has certain capabilities
- If you show them all, you get multiple perspectives, which may provide a better understanding

Everything (or anything) can be used everywhere – there is no standard methodology and choice of method is personality-dependent

Comparison of example COG at strategic vs. operational levels
- Strategic Air Systems at Strategic
- SAMs (missile systems) at Operational

Strange is used, but assumes COG already identified

Have JWAC analysis (e.g., electrical power) of targetable systems (and factors that impact targetable systems) rather than COGs
- Geography, infrastructure, players, etc.
- Analytical foci map to traditional COGs; leverage to ID Strange's CCs-CVs-CRs

JFC presents COGs through OO.
- One-to-one mapping or "n"-to-one mapping? (we think many-to-one is more likely)

JWAC does the Target System Analysis – get recommendation on how to take down
- LOC, infrastructure, geo, etc.

JWAC does SoSA, not COG analysis

JFC-provided COGs

Have all OO chain, end states, …
What I know through intel mapped to what is needed

*PMESII mapping is all subjective
Look at each element, what do we know, capability, many details
*Huge human element, so need to less subjectively and more objectively define the problem
What are potential consequences of PMESII situations
Map PMESII information to OO/COGs/effects to aid analyst critical thinking
Viz will not be main focus (maybe wizard-based approach, e.g., Turbo Tax)

How to get help: through templates, checklists, guidance on how to do analysis
Pull from lessons learned

Strategy Plans must revisit: Known-Knowns, Known-Unknowns, Unknown-Unknowns
VPT-like system infers the unknown unknowns and flags analyst attention

COG has to accommodate squishy as well as firm
"Will of people," "Religious extremism"
COG of Iraq could not be found

Barlow shows a live enemy
Stressing dynamic nature of situation—tie to visualization requirements.

Investigate what we should be doing

Analytical capability depends on # of augmentees (airmen not normally in the position), etc. Level of expertise may vary…

COG could help jump start RFI process

Federated (aggregated) population of data (controlled by ISRD)
Should control population of data structure
Make COG analysis federated as well
High level of expertise is available through reachback to Checkmate

Airmen have conducted COG analysis
Many times may not agree with Strategic view
Depends on COCOM if the COG is handed down or if SPD is participatory in its identification

Baggage associated with COG, not so with TSA

JDAMs will complicate analysis, because targeting can be more specific and can be many more potential targets suggested

Requires collaborative work
Layers should be fully interactive to accept inputs from individual tablets
Should be able to update
main display
individual views

1st pass to understand adversary and prioritized unconstrained
Targets: should → like → can?
Done with people sitting around table

Getting to Weapon-Target pairing (but at highest level)
Could we do with DIME?
Level of detail is to bomb, but not what to bomb
Example: Request military action but need flyover or basing rights, which requires a request for diplomatic action

Needs to occur in training prior to AOC (from ISRD rep in SPD)
Do COG analysis training at ISRD, IWFs, etc.

Many young airmen don't have the critical thinking skills
IF doing the work of more experienced analysts, must have templates, prompts, warnings, checklists, etc.

Structure aids so everyone can get what they need without forcing aids on those who don't need/want them

Analysts populating database
Next analysts continue the analysis
Continue on through 'n' analyst/planners

With any three analysts, can have information presented three different ways, making it difficult to recognize they are the same
Also makes traceability difficult

IPB is PowerPoint, with textual backup
Key component, trash-in/trash-out

May not get customer feedback into models and results

Dream is a live Barlow model
Don't' care about geo
Compare COAs (what happened)
*Fed by Assessment
Real-time and screen grab to play with
Highlight back to Strategy

"What should we target?" versus saying "COG"

JFACC may limit # COAs or COGs to focus on

*Where am I in plan-execute (component can have inputs)?

Joint approach may not work (other components are happy with their process)
    May be overlay each component
    Have to sell them on ideas

*Really needs to go beyond military (DIME)

Diplomatic example for AF
    Overflight, e.g., Turkey

After 9/11, reachback contributions came in, e.g., from Checkmate

AFFORs job is knowing basing
    AC problem: significant portion of plan that must change, e.g., Turkey
    Diplomatic approach

Blue COG are often ignored – need to consider (AFFOR should monitor)
    Prioritized dependent asset list – PDAL

Warden is good initial look (could use Olympic Rings)

The models do map to each other

COG (models) is data presented in different manners

"Have to stay focused on "your" mission (component), because JFC should oversee"
    Don't get stuck (peripheral effects, but mission focus)

Scale to what "I'm" looking at

Would like to see examples, e.g., Israel and Palestine, COGs and how these work (to better scope)
    Make sure OAT doesn't get overtasked trying to supply data

Org chart for PMESII needs more than lines (back brief)

Economic – Army doesn't want to wipe out infrastructure and economic

TSA should have "reconstitution" information
    Needed in COG

Notes from Cog Viz session 5, Conference Room B April 5, 2006 1415 (Interviewer 2)

Trash in = trash out. All comes down to understanding the Battlespace

Strange starts with COG, and then breaks it down.

PMESII does same

Barlow is closer to reality. Just because it's closer to reality, doesn't mean it's easier to apply.

I'd like to see all models perspectives.

This will determine where highest probability payoff is.

Not only determine COGS

Everything is being used, but Strange is most common. Different in every AOC. Depends on Strategy Chief.

I've never seen a model of the enemy put up on the data wall in the AOC.

With this asset, how much can I collect… ?

How do you handle politics?

Q. Who determines where the COG is, say in the case of electrical power?

A. A complex target analysis should have been done already.

Q. How is that presented to the Air Component?

A. Operational Objectives. JWAC will do analysis and present options.

We take a snapshot of the DIA MIDB. What can we do with this JWAC product?

They give you different options for how to take it out, how long it will be down for, etc. (JWAC does SoSA, not COG analysis)

The process is in place. But there's what should be, and there's what is. If you don't get the guidance, you make it up. (assumption).

If I take down the power, how much does this regime rely on it? Are there other countries reliant on it?

Start with political. Constrain discussion on that until done. Then we move on to the next one. Military. What are their fielded forces? Nighttime capability? Currency of pilots.

Don't think you can computer model everything. Some things are human-centric.

Federated population – not just Strategy Plans.

Nobody should be your boss's filter but you!

Q. Have we done COG analysis since Desert Storm?

A. Yes, but they didn't necessarily agree.

There's baggage associated with COG analysis, but not TSA—yet they are very similar.

Target 2000 targets, strike 2000 targets. That was strategy. Attrition was the effect.

You'll take your best shot at understanding the enemy (PMESII). Then you'll figure out what the fastest way to take him down with the asset's you've got. The targeteers will be instrumental in determining this.

What should we target?
What can we target?
What do we want to target?
Is on No-Strike List? Do we have the necessary weapons?, etc.

Bunch of guys sitting around a white board do the analysis. Break it down into bite-sized pieces.

Ultimately getting to weapon target pairings. Think any type of target (person, place, thing, etc.). Think any capability (action).
Strategy plans is looking at the outcome of TSA.
Primary vehicle is PowerPoint to CFACC. Some are 250 slides.

By and large, analysts don't have the critical thinking skills needed.

If your IPB is bad, then all subsequent analysis is bad as well.

Wardens Rings are useless. Going to be a combination of multiple models. Look at enemy and say, "this is sound."

Dream: live Barlow model—political pieces growing and shrinking.

We're abysmal at taking air strategy and showing how it contributes to the campaign strategy.

Need to look at supporting relationships.
CFACC wants someone else to have looked at all this, even if you've got a different opinion.
I'd be happy if the airmen had a seat at the CFACC's planning table.

Q. Into which tool do you want a COG system integrated?
A. I want a single application that goes out and gets all the information for me.

Preplanning for OIF

Once components brought in, you've got reach back.
Ground speed 0. Get a topic, issue, throw it out, pass it up the chain.

Q. National military strategy, etc. is it out of our area?
A. Yeah. Did we do it? Yeah.
You've created a plan that is heavily based on flying out of a certain air base.
Then you're told you can't. you can't solve it yourself. So it goes up the chain.
Then it might become a diplomatic issue.

We have been focused on the enemy. There's a blue piece that has been largely ignored.

We've got the red Barlow model (we want to attack). And we've got the blue model (we want to protect). We ignore the blue model a lot.
Which model is used is dependant upon the personality of the person using it.
Some models lend themselves to certain AORS better than others.

Don’t get wrapped around the crank about cross-component ripple effect. Worry about your own piece of the mission. The JFC should be worried about that.

System should deal with:

1) Known knowns, 2) known unknowns, and 3) unknown unknowns.
Provide a real world example of COG Viz. Maybe Israel vs. Palestine.
Don’t saddle the OA guys with yet another deliverable.
Political analysis vs: Analyst’s Notebook vs. Organizational chart

MAJCOM Interview Notes

I. COA Development Process

Start with map of enemy territory
- Map needs to be the 1-250000 view
  - Outlines of cities, Topographical data, Major highways, Lat/Long grid marks

Map where JOA (Joint Operations Area) is – where we have control

Begin categorizing activities based upon tasks listed in Mission Analysis brief (Gain AS, conduct CAS, support CFLCC)
- Would like to have a library of actions that you can drag/drop from based upon activity category (These would be Tactical Objectives)

Would like to also refer to what other components are doing ("army is moving forces here")

If doing network warfare, would like a network diagram instead of map (need for other tools) – map would give 90% solution

MILSTD 2525 symbology – GOOD

Begin to draw on map the "categories" and "actions" (Gain Air Superiority)
- Would like controls that are easier than PowerPoint!
  - Want to be able to draw the circles/squares/blotches/arrows of different line thickness
- Would like to be able to produce a COA sketch for each phase and AOD
  - May have need for adding time slices to one visualization (AOD A achieved this much, AOD B added this, AOD c added this to AOD B)
- Would like Intel to be able to add data and provide this instead of PowerPoint slides
- Would like to be able to toggle bad guy layers
- Would like to be able to brief this to Commander
  - Briefs Phase, AOD views as well as individual OO views
  - Believe this would be the CC's favorite tool
  - Need to show "refined" view, not computer generated which could be choppy…
  - Would like CC to be able to see and write thoughts down while looking at briefing
    - Allow him to circle and interact with map
    - Allow him a place to write down comments (CC guidance)
- Would like to use map to begin planning – suck OO/TO data into CPT from map
- Would like map view to updated due to changes as work products (JPITL, MAAP) are created/detailed

Extract Operational Objectives and Tactical Objectives.

Begin to break down OOs and TOs into phases against time.
- This process will begin to weed out bad ideas and will also add new OOs and TOs
- Some phases are started not based upon whether or not we are ready for the next phase, but whether or not the enemy takes action
- Phases are usually broken down like this:
  - Phase 1 – deploy (set up time)
  - Phase 2 – seize the initiative (action!)
  - Phase 3 – culminate (Need to have MES achieved by end of this phase)

All end states that define success should be achieved by the end of this phase

Phase 4 – clean up/ transition

Military plays supporting role to diplomatic/economic end states

Phases are event driven, not time driven!

CC will still set an anticipated date based upon when effects should be accomplished

Phases could possibly go on at same time

i.e., I finish up AS early. I need AS only to begin new phase tasks. I must now decide if I should free up resources for other current phase activities or begin with next phase's operations.

Will submit RFIs throughout this process

If there are multiple ways to achieve an effect – they will do all to ensure success

Will create new COAs by merging COA ideas

This is sometimes done by the commander

COA Development will produce: (believe a lot of this could be done in the COA sketch if tool is done right)

COA sketch

Operational Concept

Paragraph of what we are going to do (the HOW that is missing from mission analysis)

Key Operations Objectives List

List of forces required

Allocation planner fits here!

Current makes educated guesses by reverse engineering DMPI/sortie equiv

May have phase plan

II. Effects-based Operations — Value-focused thinking

EBO does not tell you what to do; it tells you when to stop

End state = adversarial Status System = Effect

Planning model for each chain of effects-based actions:

No action Effect — Action Effect

Actions

Effects	F	T
T	FT	TT
F	FF	TF

No action No effect — Action No effect

Air Superiority example
Accompanied by spreadsheet with value model (AirSuperiority.xls)

Air Superiority End State: Tactical Objective (TO)
Air Superiority Defensive System includes SAMs, AAA, and IADS
1. Freedom from attack or other Red action 2. Freedom for Blue action
Air Superiority employs Offensive Counterair, Defensive Counterair, and Base Defense

Concerns: SAMs, AAA, IADS

Value Model for Aircraft affected by SAMs		**Rating Score Criteria**		
	Importance			
Destroyed	.5			
Damaged	.4			
Di???	.1			

Value Model for SA2			**Rating Score Criteria & # of launches**		
SA2 launches		**Importance**	**1**	**.5**	**0**
Guided launches		.95			
	Radar	.80	2	3	5
	Optical	.20		5	10
Unguided launches		.05			
	Ballistic	1.0		5	10

Note: Observe difference in relative value—.95 vs. .05; (x • y • z) = 1 [perfect score]
Focus: Tactical Task (TT) Neutralize SA2s
Effect: No SA2 shots at my airplanes
Action: Tactical Task (TT) Destroy TEL radar

Destroy
SA2

- **TEL**
- **Radar**

(n) effect		**Actions**	
	Effects		
		FT	**TT**
		FF	**TF**

- Anticipate approximately 10-20 TTs.
- EBO: Actions taken will lead to an effect through causal linkages
- Quad chart illustrates possible outcomes

Neutralize SAMs

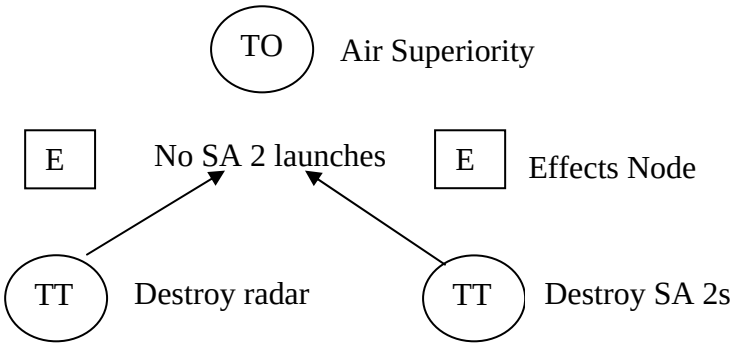
(n + 1) effect	Σ (n) effect	
	Actions	
Effects	**FT**	**TT**
	FF	**TF**

Air Superiority

(n + 2) effect	Σ (n + 1) effect	
	Actions	
Effects	**FT**	**TT**
	FF	**TF**

Operational Assessment:
OA guys don't have a way to measure effects

Use Tactical Objective (TO) as value model
Note: Can't say 0 aircraft losses = Air Superiority
Tactical Task (TT) value differs from Air Superiority Model (OO or TO)
TT only looks at SA 2 launches vs. TO looks at loss of aircraft or numbers of ground-based and sea-launched attacks
Differentiate measures of performance from measures of effect



Bay of Pigs Scenario

Mission Effects Assessment: Did my troops kill Castro
Did Castro's mistress kill him (unrelated to my actions)

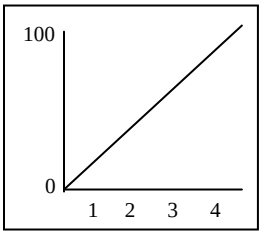
First is a true action (causal link) and a true effect (desired end state). Second is an unknown actor doing an unknown action (false action) and yet you see your desired end state (true effect).

JEFX 2004 had 12 operational objectives
1700 Tactical Tasks

Our job is to qualify and quantify goals and progress and to use visualizations to present to CFACC. CFACC cares about the number of aircraft diverted.

CFACCs have different risk tolerances. Team makes assessments to present risk ratio for actions to effects

SA2s destroyed. Goal is .8 by Day 4. Do I fly on Day 4 if effect is achieved by Day 3?



I want an allocation planner.
How many DMPIs are there vs. my actions?

Note: Colleague made a 9000 target spreadsheet for Iraq with individual DMPIs and allocation plan

You will have OB with BE #s.
DMPI identification depends on what you want.
If none, not weaponeered.
MIDB plus CAT codes against target list
Just-in-time targeting. Can't do allocations at the last minute—have to look outward.
Targeteers know IADS targets, etc. with CAT codes have a rough idea of capabilities

III. Goals

1. Thinking aids—a key to understand relationships
2. Shorten the 24-hour cycle to a continuous cycle

JFACC Planning Tool (90s)
No one understood the rule of thumb by which system operated (?)
Made guesses but didn't know the business rules embedded in system (guessed 3000 DMPIs vs. 2 known DMPIs)
Need to make business rules explicit when business logic underlies a forecast

8th Air Force has a 12 hour production cycle
CAP and Time Sensitive products (not a full JAOP)

Want tools to collaborate—not collaborative tools. That is, put decisions into tools rather than focus on making tools so "they" can see what "we" see.

Design tool to JAEP to meet MAJCOM/COCOM needs.

IV. Mission Analysis

Air Superiority is an enabler, not an effect in and of itself. Use as a critical capability to degrade political leadership

Map shows Joint Ops area in bad guy country.
Circles indicate areas where you need air superiority, naval exclusion zones, CFLCC area of operations, etc. Critical Capability might be communication and action might be to jam towers.
Tag circles as operational objectives, provide phases (groups of timing)

Now use PowerPoint slide.
Want interactive picture with metadata attached.

COA development is not done to the TT level. May have TO but may not have parent named (?)
Air component perspective good but Joint perspective better for tool. The CFC signs off on your plan anyway (not the JFACC). An electronic JAOP would be much more detailed than any paper copy could be.
The paper copy is an executive summary—but if that is what the CFC sees, that is all he has signed off on.

Does an electronic ATO foster too early precision or over-precision? Answer: No.

In such a tool, the data provided to CFC is not operational data, but is still very detailed. Now he sees a unified whole. Gantt chart in PEL—would change wording to represent his desired effects but didn't change effects.

PEL item changes broke linkages; while the activity remained basically the same
Changes require rewriting of plan.

Operational objectives don't morph over time. Effects do morph over time.
Current focus—priority, weight of effort.

Time-phased picture of plan is much more understandable than the Gantt chart. Build slides, by phase, on the map. Show end state and families of activities to achieve the end state (autopopulated by CPT)

Map display should be able to show up to four COAs across four phases. They will vary by ends, means, ways, and risk.

Disconnect between Day 10 requirements and capabilities

- Am I going to be done?
- Can I be done?
- When must I be done?

Go to JWAC. There are 10,000 DMPIs but we only need to hit 4,000. What to do to decrease them.

COA Sketch: Operational Concept (word picture plus time flow picture)

Then we flesh out the details and personalize to the bad guy country.

If one were to make that sort of tool, what sort of fidelity would be required in the map picture.
JNC (1: 250,000) vs. ONC vs. TPC

Need outlines of countries, cities, highways.

Deliberate Planning:
Mission Analysis–days to weeks
COA Development–days to weeks to months (Time-sensitive planning has short! timeline)
COA Selection–days to years (deliberate planning can take years for approvals)

Notes Acronym List

AAA	Anti-Aircraft Attack
AC	Aircraft
AF	Air Force
AFFOR	Air Force Forces
AOC	Air Operations Center
AOD	Air Operations Directive
AOG	Air Operations Group
AOR	Area of Responsibility
AS	Air Superiority
ATO	Air Tasking Order
CAS	Close Air Support
CAT	Causal Analysis Tool
CC	Combatant Commander
CC	Critical Capability
CENTCOM	Central Command
CFACC	Combined Force Air Component Commander
CFC	Combined Force Commander
CFLCC	Combined Force Land Component Commander
CGSC	Command & General Staff College
CIA	Central Intelligence Agency
COA	Course of Action
COCOM	Combatant Command
COG	Center of Gravity
CPT	Collaborative Planning Tool
CR	Critical Requirement
CV	Critical Vulnerability
DIA	Defense Intelligence Agency
DIME	Diplomatic, Information, Military, Economic
DMPI	Designated Mean Point of Impact
EBO	Effects-based Operations
F	False
IADS	Integrated Air Defense System
ISRD	Intelligence, Surveillance, Reconnaissance Division
ITS	Information Technology Systems
IWF	Information Warfare Flight
JAEP	Joint Air Estimate Process
JAOC	Joint Air Operations Center
JAOP	Joint Air Operations Plan
JDAM	Joint Direct Attack Munition
JFACC	Joint Force Air Component Commander
JFC	Joint Force Commander
JNC	Jet Navigation Chart
JOA	Joint Operations Area

JPTL	Joint Prioritized Target List
JWAC	Joint Warfighting Analysis Center
M	Military
MAAP	Master Air Attack Plan
MAJCOM	Major Command
MDMP	Military Decision Making Process
MIDB	Modernized Integrated Data Base
MILSTD	Military Standard
OA	Operations Assessment
OAT	Operations Assessment Team
ONC	Operational Navigation Chart
OO	Operational Objective
P	Political
PDAL	Prioritized Defended Asset List
PEL	Prioritized Effects List
PMESII	Political, Military, Economic, Infrastructure & Information
RFI	Request for Information
SAM	Surface-to-Air Missile
SME	Subject Matter Expert
SOF	Special Operations Forces
SoSA	System of Systems Analysis
SPD	Strategy Plans Division
T	True
TEL	Transporter Erector Launcher
TO	Tactical Objective
TPC	Tactical Pilot Chart
TSA	Target Systems Analysis
TT	Tactical Task
USMC	United States Marine Corps
VPT	Visual Planning Tool

Appendix B. Baseline Requirements

COG Visualization Requirements Identified During pre-WAW

ID	Requirement	Supporting Text
1.0	COG Visualization must support battlespace understanding	All comes down to understanding the Battlespace
1.1	COG Visualization must support multiple existing and user-defined approaches for COG Analysis against same data set (Strange, Barlow, Warden's, SoSA, etc.)	Strange starts with COG, and then breaks it down. PMESII does same. **Barlow** is closer to reality. Just because it's closer to reality, doesn't mean it's easier to apply. I'd like to see all models perspectives. Have we done COG analysis since Desert Storm? –yes, but they didn't necessarily agree. Bunch of guys sitting around a white board do the analysis. Break it down into bite sized pieces. Warden's rings are useless. Going to be a combination of multiple models. Look at enemy and say, "this is sound." Dream: live Barlow model. Political pieces growing and shrinking. Which model is used is dependant upon the personality of the person using it. Some models lend themselves to certain AORs better than others. Warden's model is the most prevalent. Is that what we're going to use? I've never heard of any of the others. You look at the rings and you hand them out to different people. Divide them by elements in the model (leadership, economics, etc.) You then decide what are the COGs for the target area. Warden's is what they are teaching. But, we need to dynamically react so people can update their buckets.
1.2	COG Visualization must support user-guided SoSA analysis, e.g., TSA options from JWAC in order to determine COGs	Who determines where the COG is, say in the case of electrical power? –a complex target analysis should have been done already. How is that presented to the air component? -Operational Objectives. -JWAC will do analysis and present options. We take a snapshot of the DIA MIDB. What can we do with this JWAC product? They give you different options for how to take it out, how long it will be down for, etc.

		JWAC does SoSA, not COG analysis If I take down the power, how much does this regime rely on it? Are there other countries reliant on it? There's baggage associated with COG. But not target systems analysis. Yet they are very similar. Strategy Plans is looking at the outcome of target systems analysis.
1.2.1	COG Visualization must show direct and indirect effects of COG within and external to the battlespace (infers global visualization).	If I take down the power, how much does this regime rely on it? Are there other countries reliant on it?
1.3	COG Visualization must assist in selecting the COGs upon which available assets deliver desired effects System Req: Load available asset capabilities Pair capabilities to COG types Visualization is implicit	You'll take your best shot at understanding the enemy (PMESII). Then you'll figure out what the fastest way to take him down with the assets I've got. The targeteers will be instrumental in determining this. What should we target What can we target What do we want to target? Is on no strike list? Do we have the necessary weapon, etc.? Ultimately getting to weapon target pairings. Think any type of target (person, place, thing, etc.). Think any capability (action). We need to identify what they rely on for various things, like power or heat.
2.0	COG Visualization must allow for identification of assumptions made during identification of COGs. System Req: ID assumptions as they are made or received Key is to capture relevant data without requiring repetitive effort from user Track and display assumptions	If you don't get the guidance, you make it up (assumption). Known knowns, known unknowns, and unknown unknowns.
3.0	COG Visualization must support the current COG analysis processes System Req: Support use of common data set Support existing and user –defined approaches Accept user-defined approach inputs	Everything is being used, but Strange is most common. Different in every AOC. Depends on Strategy Chief. The process is in place. But there's what should be, and there's what is. Warden's model is the most prevalent. Is that what we're going to use? I've never heard of any of the others. You look at the rings and you hand them out to different people. Divide them by elements in the model (leadership, economics, etc.) You then decide what are the COGs for the target area Trying to identify critical capabilities and vulnerabilities, I use a system of systems approach.

3.1	COG Visualization must support categorization of battlespace situation variables within any of multiple models (e.g., bin each variable within the selected model) System Req: Allow for dynamic situation-dependent variable creation and mapping	Warden's model is the most prevalent. Is that what we're going to use? I've never heard of any of the others. You look at the rings and you hand them out to different people. Divide them by elements in the model (leadership, economics, etc.) You then decide what are the COGs for the target area. Trying to identify critical capabilities and vulnerabilities, I use a system of systems approach.
3.1.1	COG Visualization must use models such as PMESII to classify and filter battlespace parameters or elements based on model categories	Start with political. Constrain discussion on that until done. Then we move on to the next one. Military. What are their fielded forces? Nighttime capability? Currency of pilots
3.1.1.1	COG Visualization must support breaking out PMESII other categories into user-definable subcategories	The M in PMESII is going to break out into 4 areas: Air Land Sea SOF
3.1.2	COG Visualization must support division of labor within overall collaborative efforts System Req: Support shared data	Warden's model is the most prevalent. Is that what we're going to use? I've never heard of any of the others. You look at the rings and you hand them out to different people. Divide them by elements in the model (leadership, economics, etc.) You then decide what are the COGs for the target area These models are ways to filter, they structure your work into workable pieces.
3.1.3	COG Visualization must support tracking progress COG Visualization must support coordinating work	Warden's model is the most prevalent. Is that what we're going to use? I've never heard of any of the others. You look at the rings and you hand them out to different people. Divide them by elements in the model (leadership, economics, etc.) You then decide what are the COGs for the target area
3.2	COG Visualization must allow for human interaction in determination of the COGs.	Don't think you can computer model everything. Some things are human centric.
3.3	COG Visualization must support collaboration and federated sharing of COG information and analysis data.	Federated population – not just Strategy Plans. I'd be happy if the airmen had a seat at the CFACC's planning table. (verify CFC or CFACC). National military strategy, etc., is it out of our area? Yeah. Did we do it? Yeah. Don't get wrapped around the crank about cross-component ripple effect. Worry about your own piece of the mission. The JFC should be worried about that.
3.4	COG Visualization must assist in capturing the process supported by "whiteboard" analysis	Bunch of guys sitting around a white board do the analysis. Break it down into bite sized pieces.
3.5	COG Visualization must support documentation of desired changes to current battlespace	We then talk about what each COA is trying to do. For example, this COA will attack their leadership and we think this will result in this change. Based on that change, we will then do this COA.

3.5.1	COG Visualization must support keeping the assessment and COA development effort tied to the desired end state	Are you always focused on the end state? Yes.
3.6	COG Visualization must support development of COAs	Within COA development, we write an operational or tactical objective directed at the adversary, directed at their COG. Alternative COAs really depend on how much we focus on that COG.
3.6.1	COG Visualization must support development of operational and tactical objectives	Within COA development, we write an operational or tactical objective directed at the adversary, directed at their COG. Alternative COAs really depend on how much we focus on that COG.
3.6.1.1	COG Visualization must support relating these objectives to COGs and COAs.	Within COA development, we write an operational or tactical objective directed at the adversary, directed at their COG. Alternative COAs really depend on how much we focus on that COG.
3.6.1.2	COG Visualization must support and document relating COGs to COAs	Within COA development, we write an operational or tactical objective directed at the adversary, directed at their COG. Alternative COAs really depend on how much we focus on that COG.
3.6.2	COG Visualization must support development of *multiple alternative* COAs COG Visualization must support COA prioritization	I have alternative potential plans, then analyze them against the enemy, we make a recommendation. He then chooses his preferred COA. They are blessed by the commander and we'll expand that and make that the center of the operational plan for the JAOC. COAs can usually be preceded by the word alternative. Once we choose one, that's the plan. When building one, we make assumptions. These assumptions become the focal points of the plan. We generate alternatives for each assumption. Within COA development, we write an operational or tactical objective directed at the adversary, directed at their COG. Alternative COAs really depend on how much we focus on that COG.
3.6.3	COG Visualization must support selection of *individual alternative* COAs	I have alternative potential plans, then analyze them against the enemy, we make a recommendation. He then chooses his preferred COA. They are blessed by the commander and we'll expand that and make that the center of the operational plan for the JAOC. COAs can usually be preceded by the word alternative. Once we choose one, that's the plan. When building one, we make assumptions. These assumptions become the focal points of the plan. We generate alternatives for each assumption.
3.6.3.1	COG Visualization must allow for and document approval of COA	I have alternative potential plans, then analyze them against the enemy, we make a recommendation. He then chooses his preferred COA. They are blessed by the commander and we'll expand that and make that the center of the operational plan for the JAOC. COAs can usually be preceded by the word alternative. Once we choose one, that's the plan. When building one, we make assumptions. These assumptions become the focal points of the plan. We generate alternatives for each assumption
3.6.3.2	COG Visualization must allow assumptions to be tied to the alternative COAs	I have alternative potential plans, then analyze them against the enemy, we make a recommendation. He then chooses his preferred COA. They are blessed by the commander and we'll expand that and make that the center of the operational

		plan for the JAOC. COAs can usually be preceded by the word alternative. Once we choose one, that's the plan. When building one, we make assumptions. These assumptions become the focal points of the plan. We generate alternatives for each assumption
3.6.4	COG Visualization must support continuous updating of variables that imply COGs System Req: Pub/Sub (not pull)	You need to continually update the things that change that might impact the success of your attack on those vulnerabilities.
3.6.4.1	COG Visualization must support *reanalysis* of COG variables and updating COGs and COAs System Req: Must be machine focusable on impact to success of attack (rule sets)	You need to continually update the things that change that might impact the success of your attack on those vulnerabilities.
3.6.5	COG Visualization must support differentiation of COGs between branches and sequels and between phases of conflict	Difference between COAs and branches and sequels. Operational COGs are different by mission phase. That is true for both Red and Blue forces.
3.6.5.1	COG Visualization must support selection of branch and sequel COAs	Difference between COAs and branches and sequels
3.6.6	COG Visualization must support identifying what each COA is trying to do	We then talk about what each COA is trying to do. For example, this COA will attack their leadership and we think this will result in this change. Based on that change, we will then do this COA.
3.6.6.1	COG Visualization must support generation of probable adversary response	We then talk about what each COA is trying to do. For example, this COA will attack their leadership and we think this will result in this change. Based on that change, we will then do this COA.
3.6.6.2	COG Visualization must support assessment of probable response to COA	We then talk about what each COA is trying to do. For example, this COA will attack their leadership and we think this will result in this change. Based on that change, we will then do this COA.
3.6.6.3	COG Visualization must support development/tracking of indicators for success assessment	We then talk about what each COA is trying to do. For example, this COA will attack their leadership and we think this will result in this change. Based on that change, we will then do this COA.
3.6.7	COG Visualization must support updating COAs based on action/reaction cycle (i.e., did the COA work as anticipated?).	We then talk about what each COA is trying to do. For example, this COA will attack their leadership and we think this will result in this change. Based on that change, we will then do this COA. Once you identify your COGs, and you predict something based on an event and they do something different, you must reanalyze your COGs.
3.6.7.1	COG Visualization must support requesting, receiving, and analyzing execution feedback.	We then talk about what each COA is trying to do. For example, this COA will attack their leadership and we think this will result in this change. Based on that change, we will then do this COA.

3.7	COG Visualization must support operations and operations other that war.	The mindset will be different based on mission type. I did narcotics interdiction. We looked for information to give to the Colombians so that they can handle the situation. My entire context is different because my operation is non-kinetic. I am in support of SOF missions.
3.8	COG Visualization must support multiple types of kinetic and non-kinetic operations.	The mindset will be different based on mission type. I did narcotics interdiction. We looked for information to give to the Colombians so that they can handle the situation. My entire context is different because my operation is non-kinetic. I am in support of SOF missions.
3.9	COG Visualization must support multiple types of missions.	The mindset will be different based on mission type. I did narcotics interdiction. We looked for information to give to the Colombians so that they can handle the situation. My entire context is different because my operation is non-kinetic. I am in support of SOF missions.
3.10	COG Visualization must support the different roles and tasks of the different COCOMs (e.g., multiple AORs, countries within AORs, AF tasks within AORs, etc.)	I have a problem. There is no cookie cutter solution for this. It is too situationally dependent. Korea is different than Columbia which is different than India.
4.0	COG Visualization must support identification of restraints in attacking the COGs	Is on no strike list? Do we have the necessary weapon, etc.?
4.1	COG Visualization must support capability pairing to COG	Is on no strike list? Do we have the necessary weapon, etc.?
5.0	COG Visualization must support the analyst/planner in performing COG analysis and decision-making. System Req: This may be wizard, template, checklist, etc.	By and large, analysts don't have the critical thinking skills needed.
5.1	COG Visualization must support the analyst/planner in finding and correlating data	It is typically ad hoc to figure out where to get your data Where do you get your info? Primary sources: Secret Service State Department You go wherever you can to get the information you need.
5.1.1	COG Visualization must support machine-to-machine ingestion of CIA World Fact Book formatted data	A lot of units use the CIA World Fact Book. They break it down into the standard categories. That gives the intel analysts a starting point to go and find out more about . . . the government, for example. They might look at literacy rate to tailor the pamphlets to that level.
5.1.1.1	COG Visualization must support transforming data from its original categorization to the categorization construct currently in use.	A lot of units use the CIA World Fact Book. They break it down into the standard categories. That gives the intel analysts a starting point to go and find out more about . . . the government, for example. They might look at literacy rate to

		tailor the pamphlets to that level.
5.1.2	COG Visualization must support ingestion of data from target folders	Another guy: I found lots of information digging through target folders
5.1.2.1	COG Visualization must interface to T-Bone/JTT (System Req)	Accessed SIPRNET back to CENTCOM Guys at 32nd AOG used those folders also.
5.1.3	COG Visualization must support a CIA World Fact Book model	A lot of units use the CIA World Fact Book. They break it down into the standard categories. That gives the intel analysts a starting point to go and find out more about . . . the government, for example. They might look at literacy rate to tailor the pamphlets to that level.
5.1.4	COG Visualization must support identification of indicators of potential COGs and COAs within current IPB (see templates and rule sets)	A lot of units use the CIA World Fact Book. They break it down into the standard categories. That gives the intel analysts a starting point to go and find out more about . . . the government, for example. They might look at literacy rate to tailor the pamphlets to that level.
5.1.5	COG Visualization must support traceability of IPB indicators to COG determination and COA construction (support for COA rationale and potential for machine learning)	A lot of units use the CIA World Fact Book. They break it down into the standard categories. That gives the intel analysts a starting point to go and find out more about . . . the government, for example. They might look at literacy rate to tailor the pamphlets to that level.
5.1.3	COG Visualization must support RFI generation and tracking and maintaining relationship to COGs and COAs	As an intel group, the World Fact Book gives us our generalization. We then use that to go get the nitty gritty.
5.1.4	COG Visualization must support relating RFIs to specific COGs/COAs	As an intel group, the World Fact Book gives us our generalization. We then use that to go get the nitty gritty.
5.1.4.1	COG Visualization must support maintaining the relationship between information requirements and assumptions	As an intel group, the World Fact Book gives us our generalization. We then use that to go get the nitty gritty.
5.1.4.2	COG Visualization must support reachback to multiple sources	As an intel group, the World Fact Book gives us our generalization. We then use that to go get the nitty gritty.
5.1.4.3	COG Visualization must play on the GIG (System Req)	As an intel group, the World Fact Book gives us our generalization. We then use that to go get the nitty gritty.
5.2	COG Visualization must support working with multiple standardized user-configurable data sources	I created my own database for the primary targets. Included various options, geographic data, targeting options. He plotted them on maps using FalconView on ITS.
5.2.1	COG Visualization must support working with multiple visualization capabilities (e.g., geographic, temporal, trending, managed knowledge)	I created my own database for the primary targets. Included various options, geographic data, targeting options. He plotted them on maps using FalconView on ITS.
5.2.2	COG Visualization must provide plug-in	I created my own database for the primary targets.

	infrastructure to support different user interfaces (System Req)	Included various options, geographic data, targeting options. He plotted them on maps using FalconView on ITS.
5.3	COG Visualization must support both a defined doctrinal process (especially for exercises) and personal or directed variants	In exercises they try to go by doctrine, which is not what they do in real life. In real life, the personality of the leaders guides how things are done.
5.3.1	COG Visualization must support personal or directed planning process variants	In exercises they try to go by doctrine, which is not what they do in real life. In real life, the personality of the leaders guides how things are done.
5.4	COG Visualization must track the transition from categorization of variables (e.g., Barlow's NEV, Warden's Rings, PMESII) to assessment of variables (e.g., Strange's CC-CV-CR, ENAR) to actual COA development	Trying to identify critical capabilities and vulnerabilities, I use a system of systems approach
5.5	COG Visualization must support identification and tracking of specific information elements (situation variables) leading to COG determination (see indicators req)	We need to identify what they rely on for various things, like power or heat.
5.6	COG Visualization must support differentiation between elements that analyst/planner is responsible for tracking vs. elements for which analyst/planner must develop a response	How do we filter the data? You are automatically limited. If we are covering the P. We are limited as the Air Force. There's the military P, and within that is what the Air Force can do. There are parts of the P problem that are simply not my job, but I must pay attention to some of those other elements.
5.6.1.	COG Visualization must allow the analyst/planner to readily track elements for which he/she is not responsible	How do we filter the data? You are automatically limited. If we are covering the P. We are limited as the Air Force. There's the military P, and within that is what the Air Force can do. There are parts of the P problem that are simply not my job, but I must pay attention to some of those other elements
5.6.2	COG Visualization must allow the analyst/planner to update status of elements for which he/she is responsible	How do we filter the data? You are automatically limited. If we are covering the P. We are limited as the Air Force. There's the military P, and within that is what the Air Force can do. There are parts of the P problem that are simply not my job, but I must pay attention to some of those other elements
5.6.3	COG Visualization must provide notification of status changes whenever	There are parts of the P problem that are simply not my job, but I must pay attention to some of those other elements

	the system information updates itself	
5.7	COG Visualization must support maintaining a relationship between the planner's COAs and other entities' COAs (emphasis on actions).	Do you only focus on the M? No. We are really only the M. That is all we have to bear. Application of the DIME means that we *are* the M.
5.8	COG Visualization must support relating BLUE force capabilities (assets) to potential COAs with respect to the COG(s)	The matrix is: what do I have [to bring] to bear in theater, matrixed with PMESII. In almost any plan, you can get to a certain place in lots of different ways.
5.9	COG Visualization must portray both RED and BLUE potential actions	When dealing with real world situations, you must consider this a two-sided problem. Our actions are usually to degrade his capabilities, affect his will, oppose his actions. They are trying to do the same thing to us. Within this, the COGs must be identified that allow us to have the impact we want. COGs are described as source of strength and the will to use that power. COGs lie in an overlap between capabilities and will. If I'm trying to analyze a COG, he's going to use his actions to oppose me (information, economic, diplomatic, military, etc.).
5.9.1	COG Visualization must support the analyst/planner relating COGs to a range of potential actions	When dealing with real world situations, you must consider this a two-sided problem. Our actions are usually to degrade his capabilities, affect his will, oppose his actions.
5.9.2	COG Visualization must support the analyst/planner relating proposed actions to a range of possible reactions	When dealing with real world situations, you must consider this a two-sided problem. Our actions are usually to degrade his capabilities, affect his will, oppose his actions.
5.9.3	COG Visualization must allow for identification of ways to degrade adversary capabilities	When dealing with real world situations, you must consider this a two-sided problem. Our actions are usually to degrade his capabilities, affect his will, oppose his actions.
5.9.4	COG Visualization must allow for identification of ways to affect adversary will	When dealing with real world situations, you must consider this a two-sided problem. Our actions are usually to degrade his capabilities, affect his will, oppose his actions.
5.9.5	COG Visualization must allow for identification of ways to oppose adversary actions	When dealing with real world situations, you must consider this a two-sided problem. Our actions are usually to degrade his capabilities, affect his will, oppose his actions.
5.10	COG Visualization must provide a way to display potential goals for both RED and BLUE sides.	Where does PMESII lie? This might lie in the goals of each side.
5.11	COG Visualization must provide a way to map capabilities to adversary will and to possible adversary actions dependent upon those capabilities	PMESII conditions do not necessarily map to the capabilities, will, and actions of the enemy in a direct fashion.
6.0	COG Visualization must allow analyst/planner to determine the quality of the IPB.	If your IPB is bad, then all subsequent analysis is bad as well. Known knowns, known unknowns, and unknown unknowns
6.1	COG Visualization must support documentation of perceived IPB accuracy	If you're IPB is bad, then all subsequent analysis is bad as well.

	and completeness.	
7.0	COG Visualization must make IPB available for COG analysis.	If you're IPB is bad, then all subsequent analysis is bad as well. Primary vehicle is PowerPoint to CFACC. Some are 250 slides. (on integration into which tool) I want a single app that goes out and gets all the information for me.
7.1	COG Visualization must provide insight into Unknown-Unknowns (ontological references, templates, checklists, and other guidance tools)	Known knowns, known unknowns, and unknown unknowns.
8.0	COG Visualization must allow operational level COG analysis to contribute to and be correlated with campaign level COG analysis	We're abysmal at taking air strategy and showing how it contributes to the campaign strategy. Need to look at *supporting relationships*.
9.0	COG Visualization must support alternative COG analysis conclusions	CFACC wants someone else to have looked at all this, even if you've got a different opinion Have we done COG analysis since desert storm? –yes, but they didn't necessarily agree.
10.0	COG Visualization must support escalation of required DIME actions outside the air component up the chain of command	You've created a plan that is heavily based on flying out of a certain air base. Then you're told you can't. Yu can't solve it yourself. So it goes up the chain. Then it might become a diplomatic issue.
11.0	COG Visualization must support BLUE COG analysis	We have been focused on the enemy. There's a blue piece that has been largely ignored. We've got the RED Barlow model (we want to attack). And we've got the blue model (we want to protect). We ignore the blue model a lot.
12.0	COG Visualization must leverage existing Operational Assessment Team products for input to COG analysis and status	Don't saddle the OA guys with yet another deliverable.
13.0	COG Visualization must incorporate current visualization constructs where possible	Political vis: Analyst's Notebook vis. organizational chart I created my own database for the primary targets. Included various options, geographic data, targeting options. He plotted them on maps using FalconView on ITS.
13.1	COG Visualization must support geographic, timeline, trending, and other plotting capabilities	I created my own database for the primary targets. Included various options, <u>geographic data, targeting options</u>. He <u>plotted them on maps</u> using FalconView on ITS.
14.0	COG Visualization must support all levels of expertise with assistance such as checklists, selection guides, wizards, and templates.	What is the education level? You need a way to document these areas so that if they become important, we see them. A <u>checklist</u> style format might work. A drop down menu of Warden, Strange, Barlow, PMESII. If you give the operator this option, will they know which to

		use? We can provide guidance regarding which to use. For me to accomplish my mission, I need to identify my end goal and work backwards. Example, food following a tsunami. How do I get enough food? How do I protect these people? How do I protect them from neighbors? What do their neighbors have that could threaten them? What might I do about those?
14.1	COG Visualization must allow for identification of desired end states and support working backwards to requirements to reach the desired end states.	For me to accomplish my mission, I need to identify my end goal and work backwards. Example, food following a tsunami. How do I get enough food? How do I protect these people? How do I protect them from neighbors? What do their neighbors have that could threaten them? What might I do about those?
15.0	COG Visualization must help move COG analysis from subjective to objective	*PMESII mapping is all subjective Look at each element, what do we know, capability, many details *Huge human element, so need to less subjectively and more objectively define the problem What are potential consequences of PMESII situations Map PMESII information to OO/COGs/effects to aid analyst critical thinking Viz will not be main focus (maybe wizard-based approach, e.g., Turbo Tax)
15.1	COG Visualization must allow for identification of subjective vs. objective assessments	*PMESII mapping is all subjective Look at each element, what do we know, capability, many details *Huge human element, so need to less subjectively and more objectively define the problem
15.2	COG Visualization must allow for identification of potential consequences of PMESII situations	What are potential consequences of PMESII situations Map PMESII information to OO/COGs/effects to aid analyst critical thinking Viz will not be main focus (maybe wizard-based approach, e.g., Turbo Tax)
15.3	COG Visualization must map PMESII information to OOs/COGs/effects	What are potential consequences of PMESII situations Map PMESII information to OO/COGs/effects to aid analyst critical thinking Viz will not be main focus (maybe wizard-based approach, e.g., Turbo Tax)
15.4	COG Visualization must provide guidance on modeling and analysis techniques	What are potential consequences of PMESII situations Map PMESII information to OO/COGs/effects to aid analyst critical thinking Viz will not be main focus (maybe wizard-based approach, e.g., Turbo Tax)
16.0	COG Visualization must support nodal analysis	How do I show you all of this? Is it strict nodal analysis?

		Show nodes with most things going to it? Show nodes with the most critical connections?
16.1	COG Visualization must provide multiple algorithms for nodal analysis to provide flexibility in views and assessments	I could have something really important that has only one relationship. That could be the most important node and it has only one pathway.
16.2	COG Visualization must allow flexibility in the analytical process and level of detail required to complete the planning task	I can imagine myself putting these pieces together, but what's the point? We need to maintain focus on the end state. If the answer bubbles to the top, why waste time filling out a model?
16.2.1	COG Visualization must flag rapid decisions made during a compressed planning cycle	I can imagine myself putting these pieces together, but what's the point? We need to maintain focus on the end state. If the answer bubbles to the top, why waste time filling out a model?
16.2.2	COG Visualization must allow for assessment of and feedback on rapid decisions made during a compressed planning cycle	I can imagine myself putting these pieces together, but what's the point? We need to maintain focus on the end state. If the answer bubbles to the top, why waste time filling out a model?
16.2.3	COG Visualization must allow for rapid analysis of COGs that bubble to the top	I can imagine myself putting these pieces together, but what's the point? We need to maintain focus on the end state. If the answer bubbles to the top, why waste time filling out a model?
16.2.4	COG Visualization must allow for identification of levels of confidence in solutions	I can imagine myself putting these pieces together, but what's the point? We need to maintain focus on the end state. If the answer bubbles to the top, why waste time filling out a model?
16.3	COG Visualization must provide methods to visualize and denote lines of effect	I like the Red Thompson's lines of effect. That works for me. It provides a roadmap for where you might go
17.0	COG Visualization must support "brainstorm-style" collaborative work with shared visualizations and real-time communication	"I will never get on a computer to get this going. I grab creative people, get together, and brainstorm. To be constrained by a computer program or tool is not conducive to what I try to do at the beginning."
18.0	COG Visualization must pull information from "lessons learned" (e.g., mission analyses, analyst notes, etc.) and add to existing knowledge base to update analyst guidance	Strategy Plans must revisit: Known-Knowns, Known-Unknowns, Unknown-Unknowns VPT-like system infers the unknown unknowns and flags analyst attention
19.0	COG Visualization must accommodate uncertainty, incomplete analyses, and fuzzy concepts	COG has to accommodate squishy as well as firm

PART III: ATO VISUALIZATION REPORT

Table of Contents

Introduction

This report documents a process utilized to generate initial interface design concepts for visualization of the air tasking order (ATO) within the combat planning cell. This project began as a two-pronged effort: data wall concepts and the development of visualizations for use within the Strategy Plans cell. As the data analysis progressed, the focus moved to the ATO visualization, only with emphasis starting at the Strategy Plans cell and settling on the combat planning cell. Though those shifts in focus were costly in terms of time and budget, they were a valuable process to go through for both the Government and SRA International, Inc. (SRA). This discovery process allowed us to identify an area in critical need of visualization and support tools. That area, the combat planning cell within the AOC, is dramatically under supported in terms of tools that support cognition, decision making, workload, and data input. The combat operations cell tends to receive the most attention, while the planning cell is often ignored. Although it's not the focus of this effort, future tool development must focus on the collaborative elements that exist between combat operations and planning. We understand tools are currently being developed, we can only hope that these tools contain features that support collaborative team performance as well as individual task completion.

Cognitive Task Analysis

Cognitive Task Analysis (CTA) is a set of methods aimed at describing the cognition required for task performance. This report describes a CTA process used to understand the cognitive demands of personnel operating within a planning cell of the Air Operations Center (AOC). The first round of interviews was conducted with members of the Strategy Plans cell. Following that data collection effort, the team chose to focus on the Combat Plans cell. Following this decision, we interviewed individuals from that cell in an attempt to capture their decisions, judgments, and other cognitive demands associated with optimal performance within Combat Plans.

In a general sense, CTA provides methods for the researcher to identify the cognitive processes that underlie skilled performance of tasks. These cognitive processes can include the ability to:

- control attention,
- use working memory and long-term memory,
- make perceptual discriminations between subtle cues and patterns,
- form situation awareness,
- construct mental models,
- apply strategies and heuristics to make decisions, solve problems, and plan,
- derive inferences,
- recognize typical and anomalous events,
- monitor and adapt cognitive processes (metacognition).

CTA techniques and methods are designed for capturing each of these cognitive processes. The specific CTA techniques employed depend on the goals of the study, the domain being studied, and the cognitive processes of greatest interest to the researcher. For this project, SRA employed CTA techniques to focus on the decisions made by individuals in the AOC.

This project applied this process to generate a set of decision requirements tables and concepts to aid combat planners to visualize and develop an air tasking order (ATO). Due to scheduling and/or access issues, we were only able to conduct a small set of interviews. Yet, these interviews

provided great insight into the process and cognitive requirements necessary for successful completion of the tasks. We were also fortunate to attend a set of focus groups in which we were able to generate discussion regarding the current processes, as well as to gain feedback on "how it should be." During these sessions, we asked the focus groups to imagine a perfect tool suite to help with planning. Their brainstorming sessions provided innovative ideas that influenced our visualization concepts.

This limited set of interviews required a reliance on several publications in order to support the CTA. These readings provided an understanding of the desired process for ATO planning as well as doctrinal information regarding the interactions of combat plans with other AOC members (see Appendix A). However, these readings did not provide enough decision context. They simply provided background information. The interviews were needed to bring the cell to life, to learn about the decision process, and to understand where things work well and where they break down.

The data analysis was guided by several models, including the Recognition-Primed Decision Model (RPD) (Klein, 1989), the Advanced Team Decision Making (ATDM) model (Zsambok, Klein, Kyne, & Klinger, 1993), and several theories on problem solving (Bennett, & Flach, 1992 and Jones & Mitchell, 1995). These models and theories provided the necessary focus for the team to rapidly develop the data that appears in the Appendices of this document.

The RPD model was developed based on field studies of the way experienced personnel actually make decisions. The model explains how people can use experience to react rapidly, and how they can make good decisions without having to contrast options. The model has been tested and has been supported by different research teams working in a great variety of settings.

The RPD model attempts to describe what people actually do under conditions of time pressure, ambiguous information, ill-defined goals, and changing conditions. The model focuses on experienced agents, working in complex, uncertain conditions, who face high consequences for their actions. The model addresses situation awareness and problem solving as a part of the decision-making process.

The Advanced Team Decision Making (ATDM) model includes ten behaviors critical to a team's success. Developed within a project for the Army, the model is applicable for strategic and tactical teams, as well as planning and action teams. The model has been evaluated at several locations within the military (i.e., Army War College and Industrial College of the Armed Forces) and has been applied to wide variety of domains (Klinger & Klein, 1999). The ATDM model is organized around three critical team elements:

- Team Identity
- Team Self Monitoring
- Team Conceptual Level

The ATDM model is not an all-inclusive model of how teams perform. Instead, it provides guidance as to the behaviors that matter most. Successful teams exhibit the 10 behaviors identified in the model, and less successful teams do not exhibit one or more of those behaviors. This model, therefore, is a valuable tool for assessing team performance. Using it as a framework, one can bypass unnecessary team process issues and focus on those that matter most.

The two elicitation methods used during this effort are described in the following sections. Those methods, the Team Knowledge Audit (TKA) (Klinger, 2003) and the Critical Decision Method (CDM) (Klein, Calderwood, & MacGregor, 1989), were selected based on the data these methods provide.

Specifically, the TKA employs a set of probes designed to describe types of domain knowledge or skill and elicit appropriate examples. The goal is not simply to find out whether each component is present in the task, but to find out the nature of the skills, specific events where they were required, strategies that have been used, and so forth. The probes, which stem from the behaviors described in the ATDM model, are the starting points for conducting this interview. From the probes, real-world examples can be elicited. Then, the interviewer asks for specifics about the examples in terms of critical cues and strategies of decision making. This is followed by a discussion of potential errors that a novice, less-experienced team member might have made in this situation. The examples elicited with the Team Knowledge Audit do not contain the extensive detail

and sense of dynamics that more labor-intensive methods such as the Critical Decision Method incident accounts often do. However, they do provide enough detail to retain the appropriate context of the incident.

The CDM technique provides much-needed context to the decision process. A CDM session is organized around a specific event in which the team member has played an active role. The interviewers elicit an account of the incident, and then drill progressively deeper into several aspects of the event in order to uncover the decisions and judgments made during the incident; the cues, factors, and other types of information employed; and the interaction that occurred with other team members. The goal of the CDM is to elicit a context-rich example of how the team member functions on the team. The value of the CDM lies in collecting a set of highly detailed incident accounts from various individuals with varying levels of expertise. Taken together, CDM data provide an excellent description of the cognition involved in the completion of tasks and subtasks, as well as the information-sharing and decision-making required for team task performance.

The Cognitive Task Analysis consisted of several phases:

- Focus groups were used at the pre-Warfighter Analysis Workshop (WAW)
    - Time was split between discussions regarding the application of a data wall and conceptual discussions regarding ATO visualization display designs
- Nine interviews were conducted at 505th TRS, Hurlburt, AFB
    - A mixture of Team Knowledge Audit and Critical Decision Method was enlisted
    - Interviews were also split between information regarding the application of a data wall and potential methods for application within ATO visualization displays
    - Raw notes from these interviews are included in Appendix B.
- Two interviews were held with Subject Matter Experts (SMEs) at SRA
    - Informal interviews and brainstorming sessions were also employed

Summary of Findings

Combat Planners are tasked with refining high level planning guidance passed to them from the Strategic Planning cell. In Combat Plans, individuals develop fairly detailed plans regarding packages, missions, and targets. At the outset, we focused on usability issues, as well as helping them with resource allocation in the areas of tankers and suppression of enemy air defense (SEAD) assets. Through the course of the effort, we began to realize that individuals start with targets and work "out." That is, they organize their work around targets and move out from there in terms of aircraft allocation (both fighters and support). Given this finding, we modified our visualization concepts to better support their process.

Our analysis of the data provided us with the following high level areas of focus for a visualization tool.

- Targeting Decisions
    - Munitions
    - Packages
    - Timing
    - Coordination
- Allocation Decisions
    - Tankers
    - SEAD
    - Units
- Visualization issues
    - Fly/No fly zones
    - Weather
    - Enemy locations
- Usability Issues
    - Minimize typing ("fat fingering")
        - More drag and drop
    - Better utilization of mouse clicks
        - Right click for more information

- Better use of “mouse overs”
- Ability to save preferences
- Ability to quickly access relevant portions of previous ATOs
    - Ability to cut and paste from previous ATOs

Appendix C provides initial visualization concepts and supporting process descriptions for Combat Plans.

Conclusions

Combat Planners are faced with classical naturalistic decision making issues. They operate in an environment of high time pressures, high stakes, limited resources, conflicting goals, uncertainty, and organizational constraints. The systems they use require massive user input and dramatically increase workload, chance for error, and distraction. These systems do little to support critical cognitive elements that are intrinsic to planning. Current systems don't let planners ask "what if?" questions, i.e. they don't support replanning, efficient resource allocation, nor do they provide adequate visual representations, including simulating the entire mission in a time compressed manner. Future systems must consider these critical cognitive elements at the outset of development.

At the collaborative level, much work needs to be done to identify the critical collaborative elements across all planning cells, combat cells, and assessment cells. Simply generating one system for all will not solve the problem. For example, how much of the "behind the scenes" contingency development should be passed with the plan into operations? What is the best method for transferring information from the strategic planners to combat planners? What data should be transferred? Should individuals involved with the plan move with that plan as it goes from cell to cell? How, and what type, of feedback or information should come *back* to combat and strategic planning during and after mission execution? How should that information returning to combat and strategy plans be catalogued, used, etc?

This effort has provided a starting point for the development of effective, performance changing visualization tools for use within combat plans. At a time when reduced manpower and increases in technology are at the center of nearly all research efforts, a user-focused process has begun to minimize the impact of manpower reduction while still increasing performance. The future of tool development will require a more extensive analysis of the tasks, cognitive elements, and workload issues within all planning cells. From there, collaborative, cognitively aligned tools can be developed that could radically increase operator and team performance.

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Appendix A. Combat Plans and Combat Operations Division Understanding

Combat Plans Division Personnel Description

Chief of Combat Plans (CCP)

Targeting Effects Team (TET) Tasks

1. Task-organize personnel assigned or attached for augmentation, to optimize the specific contributions of individual officers, civilians, and duty technicians.
2. Ensure personnel receive sufficient "spin up" training to accomplish the mission.
3. Establish procedures to ensure the TET provides complete, accurate, properly formatted, and timely inputs to theater battle management applications using standard formats. Effect quality control measures to ensure accuracy of data inputs, worksheets, and other baseline planning materials.
4. File and store critical JIPTL planning materials and all published documents, to include detailed target worksheets, briefings, and any supporting working papers.
5. Maintain access to joint target list (JTL), RTL, and NSL.
6. Develop the C/JFC's JIPTL. Obtain the integrated TNL from the Target Development Cell as the basis for formulating the daily targeting plan.
7. IO planning will be based on overall C/JFC and COMAFFOR or C/JFACC objectives. Creative cross-flow of information can enable dynamic conventional and non-conventional planning scenarios. IO actions, particularly those directly supporting a specific ATO mission, require a high level of integration into the ATO timeline. IO integration with all other operations across the CPD and COD ensures synergistic effects to most effectively cripple the enemy's war fighting capability.
8. Synchronize air and space targeting among the respective components. Provide a macro-level feasibility review, coordinate, and deconflict initial mission planning across the components. Identify and assign targets uniquely suited for attack by air and space resources that need to be tasked prior to the MAAP, as well as targets best suited for supporting component efforts in the deep battle.
9. Validate targeting solutions for kinetic and non-kinetic attack to achieve desired effects against prioritized targets.
10. Validate weaponeering solutions for achieving desired effects against selected DMPIs/targets.
11. Coordinate with the C2 Plans Team Chief to ensure the MAAP Team uses the appropriate ACO, JCEOI, and JRFL.
12. Review all previous assessments pertaining to current JIPTL development.

The TET reports to the CCP.

Members are:

- TET Chief
- Target Planners
- ATO Coordinators
- Information Operations Planner

- JAG
- Space Planner
- EW Planner
- Collection Manager

Master Air Attack Plan (MAAP) Team Tasks

1. Task-organize personnel assigned or attached for augmentation, to optimize the specific contributions of individual officers, civilians, and duty technicians.
2. Ensure personnel receive sufficient "spin up" training to accomplish the mission.
3. Establish the MAAP Team battle rhythm for sustained execution planning.
4. Establish procedures to ensure the MAAP Team review the most current version of the ROW, all detailed execution plans, and supporting SPINS required to develop the daily MAAP.
5. Ensure the MAAP Team develops relevant SPINS as required.
6. Develop MAAP Team processes to facilitate timely generation of the daily MAAP.
7. Establish procedures to ensure the MAAP Team provides complete, accurate, properly formatted, and timely inputs to theater battle management applications using standard ATO format. Effect quality control procedures to ensure accuracy of data inputs, worksheets, and other baseline planning materials.
8. Coordinate STO capabilities into combat planning.
9. Coordinate with ATO Production Team Chief to attain a working ABP.
10. Coordinate with the C2 Plans Team Chief to ensure the MAAP Team uses the most current ACO, JCEOI, and JRFL.
11. Provide the TET with air and space resource capabilities for estimating DMPI servicing capability.
12. Ensure support from METOC and space personnel in the development of the MAAP.
13. Develop a standard MAAP brief to obtain C/JFACC approval prior to ATO production.
14. Review the most current version of the ROW, all detailed execution plans, and supporting SPINS required to develop the daily MAAP.
15. Develop and update a sortie flow plan for all C/JFACC assets based on sustainable aircraft generation rates and utilization during a nominal ATO period.
16. Achieve situational awareness to enable effective planning by reviewing all relevant information regarding the mission, battlespace, and resources.
17. Develop the overarching MAAP for the particular ATO period considering the effects-based requirements, operational context, and environment. Define initial force employment packages to include support requirements, approximate target areas and vulnerability windows, sequence of attacks, and flow of air and space forces into and from the target areas.
18. Plan, coordinate, and task assets available for C/JFACC tasking, as required.

The MAAP team reports to the CCP.

Members are:

- MAAP Team Chief
- MAAP Planners

Air Tasking Order (ATO) Production Team Tasks

1. Task-organize ATO Production Team personnel assigned or attached for augmentation, to optimize the specific contributions of individual ATO duty officers and duty technicians.

2. Ensure ATO Production Team personnel receive sufficient "spin-up" training to accomplish the mission.
3. Establish the ATO Production Team battle rhythm for sustained ATO production.
4. Establish procedures to ensure ATO Production Team personnel review the most current version of the ROE, all detailed execution plans, and supporting SPINS, as required, to develop and produce the ATO/ACO.
5. Ensure the ATO Production Team creates and maintains accurate planning databases in the theater battle management system and/or applications.
6. Ensure the ATO Production Team supports compilation and publication of relevant SPONS, as required.
7. Develop ATO Production Team processes to facilitate timely production of the daily ATO.
8. Develop effective quality control procedures and conduct a comprehensive ATO review prior to obtaining C/JFACC approval and ATO publication and dissemination.
9. Establish procedures to track transmission and timely receipt of the ATO.
10. Import SPINS, to include any created in the RSTA Annex, as required.
11. Coordinate and input to ATO air refueling assets available for C/JFACC tasking.
12. Develop and maintain a comprehensive address list of approved ATO recipients and coordinate redundant procedures for ATO dissemination with the communication support team.
13. After obtaining approval for release, disseminate the ATO to tasked units and agencies by the most expeditious means available.
14. File and store critical planning materials and all published documents to include the daily ABP, ATO, ACO, as well as the supporting SPINS.

The ATO production team reports to the CCP.

Members are:

- ATO Production Team Chief
- Non-commissioned Officer in Charge (NCOIC) ATO Production Team
- TBMCS AODB Manager
- ATO Production Team Technicians

C2 Planning Team Tasks

1. Task-organize C2 Planning Team personnel assigned or attached for augmentation, to optimize the specific contributions of individual duty officers and duty technicians.
2. Ensure C2 Planning Team personnel receive sufficient "spin up" training to accomplish the mission.
3. Establish the C2 Planning Team battle rhythm for sustained ACO production.
4. Establish procedures to ensure C2 Planning Team personnel review the most current version of the ROE, all detailed execution plans, and supporting ATO SPINS required to develop detailed execution plans and produce the ACO.
5. Ensure the C2 Planning Team creates and maintains an accurate planning database of the ACMs in the theater battle management application.
6. Ensure the C2 Planning Team develops C2 SPINS as required, incorporating host nation, allied, and other Service inputs into appropriate portions of the ATO, SPINS, and data link tasking documentation.
7. Develop C2 Planning Team processes and establish procedures to collect inputs and develop detailed execution plans, to include the ACP and ADP.

8. Establish procedures to evaluate existing airspace control systems and determine changes necessary to fulfill air traffic control requirements, ensuring seamless integration with air defense, theater missile defense (TMD), and joint/combined air and space operations.
9. Ensure the C2 Planning Team inputs are complete, accurate, properly formatted, and timely ACMs to theater battle management applications using standard ACO formats.
10. Airspace Management.
11. Air Defense Planning. The C2 Planning Team prepares comprehensive air and missile defense plans. Based on the availability of airborne and ground-based weapon systems, data link architectures, and tactical C2 relationships, the primary outputs of this effort are the ADP, TACOPDAT and OPTASK LINK messages.
12. C2 Architecture Planning. The C2 architecture planners develop the C2 architecture to support air and space operations.
13. C2 Communications Planning. The C2 communication planners work closely with all joint flying, C2, and airspace management elements tasked in ATO/ACO to collect their communication/frequency requirements. They in turn coordinate these requirements with the C/JFACC and AOC frequency manager for inclusion in the overall JCEOI. The C2 communication planners will coordinate with the frequency manager for all necessary frequencies and call signs to build the supporting communications sections of the SPINS portion of the ATO and to provide to the ATO mission planners.

The C2 Planning Team reports to the CCP.

Members are:
- C2 Planning Team Chief
- C2 Air Defense
- C2 Architecture
- Data Link Architecture
- Airspace Managers
- C2 Communications Planners
- Air Support Planners
- Augmented by other Service and Component liaisons

Combat Operations Division Personnel Description

Chief of Combat Operations (CCO)

Offensive Operations Team Tasks

1. Supervise offensive operations during each shift with special emphasis on integrating all offensive and support operations.
2. Monitor the current offensive air and space operations and advise the CCO or SODO of dynamic mission requirements and resource status.
3. Recommend immediate changes to the ATO when the situation dictates.
4. Assist CCO and SODO in pre-employment, execution, and post-employment duties and responsibilities.
5. Review AOD, ATO folder, and all other pertinent documents.
6. Use system applications to accomplish mission.
7. Provide battle damage, operational, and process assessments when available.
8. Request ACO changes as required.

9. Monitor availability of all tasked air and space forces.
10. Suggest changes to missions of the air and space operation, which must be coordinated through various agencies inside and outside the AOC.
11. Coordinate with subordinate units of the TACS (especially the ASOC/tactical air control party [TACP] for the CAS/interdiction cells).
12. Evaluate the degree to which actual operations are meeting ATO objectives.
13. Pass on critical information to/from respective WOCs and platforms concerning air raid warnings, significant battle damage, unexpected changes, diverting aircraft, and airfield status.

The Offensive Operations Team reports to the CCO.

Members are:

- Senior Offensive Duty Officer (SODO)
- SODO Technician
- Offensive Operations Team Members
  - EW/SEAD Duty Officers
  - Close Air Support Duty Officers
  - Command and Control Duty Officers
  - Interdiction Duty Officers
  - Operations Duty Officers
  - Tanker Duty Officers
  - Airlift Duty Officers
  - Dynamic Targeting Cell
  - Operations Duty Technicians
  - IO Duty Officers/NCOs
  - CSAR Duty Officers

Defensive Operations Team Tasks

1. Supervise defensive operations during each shift with special emphasis on integrating all defensive and support operations.
2. Monitor the current defensive air and theater missile defense operations and advise the CCO of dynamic mission requirements and resource status.
3. Recommend immediate changes to the ATO when the situation dictates.
4. Assist CCO and SADO in pre-employment, execution, and post-employment duties and responsibilities.
5. Review appropriate documents such as AOD, ATO Folder, ACO, and ATO.
6. Conduct briefings.
7. Coordinate with other AOC teams/cells as required.
8. Provide inputs to BDA and other assessment as required.
9. Provide inputs to the SITREP.

The Defensive Operations Team reports to the CCO.

Members are:

- Senior Air Duty Officer (SODO)
- SADO Technician
- Defensive Duty Officers

- Defensive Duty Technicians
- Command and Control Duty Officers
- Defensive Counterair Duty Officers
- AWACS Duty Officers
- JSTARS Duty Officers
- Theater Missile Defense (TMD)
  - Theater Missile Defense Officers
  - Theater Missile Defense Technician

SIDO Team Tasks

1. Provide situational awareness, threat warning and identify/amplify tracks/targets in support of dynamic targeting.
2. Monitor execution of the current day's ATO and work with the SODO's Dynamic Targeting Cell to provide direct support (target identification, targeting data, weaponeering, BDA, etc) to the COD's re-role, dynamic, and TST targeting processes.
3. Monitor the execution of the ATO and RSTA Annex and in coordination with RDO/ISR Platform LNOs and the SIDO, work with the CCO, SADO, and SODO to dynamically adjust ISR assets and Processing, Exploitation, and Dissemination (PED) nodes to meet the current situation.
4. Manages the ISR assets assigned or made available to the J/CFACC.
5. Provides real-time exploitation/support (IMINT, MASINT, ELINT, and COMINT) to the COD during current ATO execution.
6. Coordinate re-tasking and adjustment of PED nodes as required due to emerging collection requirements and battlespace changes.

The SIDO Team reports to the CCO.

Members are:

- Senior Intelligence Duty Officer (SIDO)
- SIDO Team
  - Intelligence Duty Officers/Technicians
  - Target Duty Officers/Technicians
  - ISR Operations Duty Officers/Technicians
  - RDO/ISR Platform LNOs
  - Multi-INT Exploitation Cell (MEC)
  - PED LNOs

Interface Control Team Tasks

1. Based on guidance from the AADC and the OPLAN, determines data link participants, their equipment capabilities and limitations and respective needs.
2. Assists C2 Plans in the design of the data link architecture and production of the OPTASK LINK.
3. Ensures optimum Data Link connectivity by monitoring the Data Link and directing changes as necessary.
4. Manages the data link network.
5. Provides the C/JFACC with a consolidated and accurate air picture.
6. Provides direction to attached units relative to alert status.

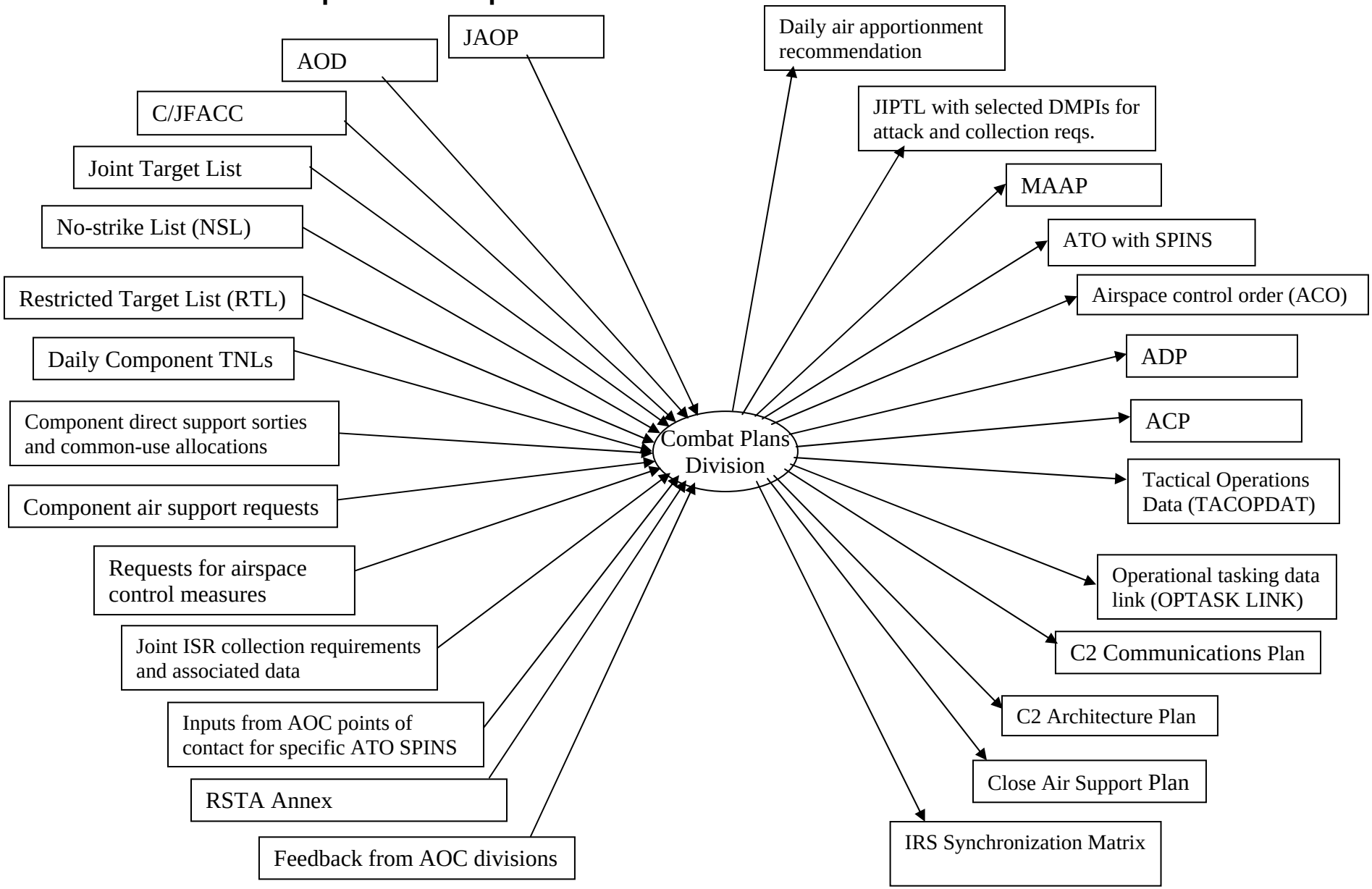
7. Produces and maintains the Recognized Air Picture (RAP) by managing the pictures produced by subordinate C2 units.
8. Coordinates with the Operations Common Operational Picture (COP) Manager for the air component input to the COP.
9. Builds and disseminates the multi-tactical data link (TDL) air picture used to support situational awareness for combat operations and for exchange of digital messages.
10. Provides multi-TDL connectivity for machine-to-machine interoperability supporting J-series message exchange for dynamic targeting and prosecution of DT/TST operations.
11. Data link architecture development/execution.
12. GCCS COP development.
13. Provides management of surveillance operations.

The Interface Control Team reports to the CCO or the SADO (as designated by the CCO).

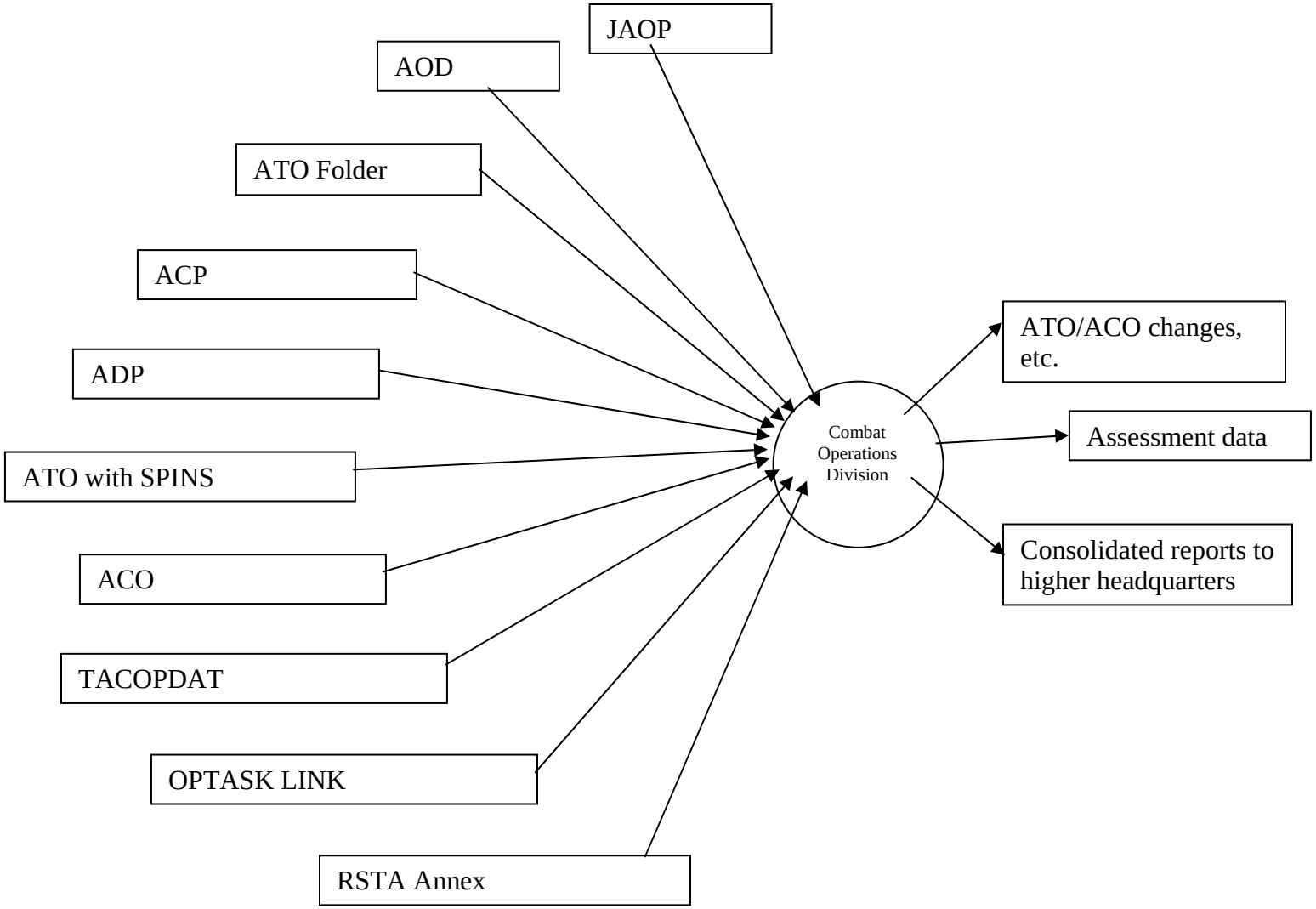
Members are:

- Interface Control Officer (ICO)
- Link 11 A/B and 16 Managers
- Track Data Coordinators
- Track Data Technicians

Combat Plans Division Inputs and Outputs



Combat Operations Division Inputs and Outputs



Appendix B. Interviews at 505th TRS

Interview 1:

Current posn: 505TRS/DOC, C2 Duty Officer

Background includes: AWACS, Exercise Plans (Okinawa), Contingency Plans, C2 exercises, 16 AF (AFFOR, JFOR staffs), Curriculum, ATO visualization

- ATO Mission Planning
  - Flow, color, callsign, mission number, time-on-target (TOT), refueling for 4-hour glance of packages
  - Filtered up to what TBMCS has nowadays
  - "ESTAT (Execution Status) is great if it works correctly"

- As a C2DO (or any posn on the Combat Ops floor), would like to see: Geography (airspace control measures), ESTAT picture, comms with AOC

- "ADOCS has a nice "Find" function
- Not familiar with Targeting, Weaponeering, Intel
- C2PC, Unix-side map, along with ADOCS, for SA
- TST coordination displayed on Data Wall

- Geography:
  - Combat Air Patrols (CAPs), air refueling, C2 orbits
  - TST CAPs (tankers and air assets for the day)
  - Target locations, red force locations
  - Blue air bases

  - "C2DO needs to know everything, but needs to be able to filter data"
  - "(schoolhouse) needs to teach how to sort and filter"
  - "love ESTAT because it looks like Excel; you can eliminate a lot of duplicated info"
    - Graphics and text
  - Text side: mission number, callsign, number and type of aircraft, mission, package ID,
  - Graphical side: actual time of departure, on-station, air refueling time, TOT, color-coded lines for status, number and type of aircraft
    - These should be sorted and filtered accordingly
  - "Most of the defensive guys know how to use the filtering, but offensive guys usually do not since there are so many of them"
  - C2 net
  - IWS (Info WorkSpace): uses IWS Chat function

- Full-up TMBCS in the schoolhouse (w/ no SIPRNet feed)
- ESTAT provides an ATO visualization that is adequate; may want to add a feature that filters out text
  - Has not used ESTAT for a large number of aircraft
  - ESTAT is part of TBMCS
- Joint Defensive Planning Tool: modeling tool for Planning, not Ops

Data wall:

- TST display is good
- "no filtering" seems to occur; need a way to convert feeds (Data link, Blue Force Tracker, etc.) into a layman's language
  - Translator for symbology is important
- "End-of-course exercise is not real, but useless"
- Important info (for data wall) is: high-priority taskings, air defense warnings, army's ground picture

Interview 2:

Current posn: Senior C2 Analyst, Ops Manager

Background includes: CENTAF, A3, A5, AOC Director, Weasels, F-4s, A-10s, AOC C2, AOC TTP

Data Wall:

As the AOC Director, there are certain things I need to see:

- "COP is useful only when measured against the plan"
- ICC (NATO TBMCS) – everyone in NATO uses ICC, except for the U.S.
  - COP (AOR), aircraft, callsign, allows a comparison of COP and planned ATO
  - COP is probably not looked at very much
  - Airspace deconfliction is important
  - ESTAT does well with flow
- Most tools do not teach you how to do a good job; they don't teach you how to better do what you do
- COP must be "zoomable" into area of interest (CAS, TST, CSAR, etc.)
- In-flight emergencies
- Blue Force Tracker
- Part Task Trainer (PTT))
  - ICC training capability
  - 2-terminal thing, build ATOs, modeling and planning, fly ATOs over and over, shoot down bad guys
- 24-hour flow—personal preference

- Looking at flow should allow you to see any gaps (airspace deconfliction)
- Filtering allows you to see defensive and offensive
- Predator, U-2, CAP, air defense, protection for strike packages
- Tool will help planners as well
- Tool should display change to the ATO
- As AOC Director, used the data wall throughout the day or when someone brought something to attention
    - "Would probably benefit everyone to see their phase (role) in the overall plan."
    - Trails of aircraft (breadcrumbs)

ATO Visualization

- Air refueling tanker planning is not connected to MAAP Toolkit but probably should be
- ATO visualization tool might graphically display when the aircraft is going to run out of gas and whether or not the pilot will be able to complete the mission
- Filter capability—just SEAD or DCA flow
- Considers ESTAT a good ATO visualization tool
- Most folks go back to using a whiteboard from the computer to do the ATO
- Collaboration is important
- Potential feature: drag and drop of routes should be a potential feature
- Displaying assets' capabilities, ROE, limitations, coalition nation and host nation assets

Interview 3:

Current posn: 505 TRS/DOC Flight Commander

Background includes: B1 Weapons System Officer, DESERT FOX, Mission Planning Cell

- ESTAT is primary tool; many varied applications on TBMCS
- Primary concern: is the tool manageable? – 3,000 sorties is a lot, 150-200 is manageable
- "ESTAT is Excel from hell"
- Striker perspective: targets, threats, refuelers, status of strike packages, status of strikes—destroyed?
- COP doesn't necessarily display targets
- PTT displays ATO as it's being played out through TBMCS; not a 3D view, but it should be
- Prioritized targets list—on screen
- Refueler plan is key; deconfliction is key
- "F-117 is going away soon"

1400 – Lt Col

Current posn: 705 TRS/DO

Background includes: C2WAC, strat div planner, JSSE, CSSE, AOC Director, chief of plans, chief of ops, OTCP (tier 3), Cell and team chiefs, TST, Combat ops, MAAP and combat ops, instructor

Data Wall:

- Automated stuff – doesn't use it
- ADSI feed – will look at it; more real-time
- MAAP Brief, bits of info
- "ADOCS is good enough"
- If I had my choice, I'd want to have a link-16 picture as a COP
- DLARS—tested at last JEFX, "ESTAT tool for TBONE", real-time data (tied to link-16)
- Seeing threats as they're populated
- Rover feeds, predator feeds
- Data wall might include: Link-16 COP (or ADSI) or some other real-time feed; CAS stuff; BCD; ROE, Guidance; JIPTL, MAAP
- ESTAT should contain the most updated info
- ADOCS (Army's system) shows what's planned
- Tailor ESTAT to log-in, remember preferences whenever ADOCS does not
- Speech recognition would be a great feature; operators already have headsets and microphones on at their positions
- My perfect tool:
  - ADOCS-based; ADOCS right-click to find on a map
  - DLARS + ESTAT + Joint Targeting Toolkit
  - Point and click, right click
  - COP driven by Link 16
- Existing apps do a fairly good job of ATO visualization
- Priority tools I use: ADOCS, ESTAT, IWS for collaboration

Interview 4:

Current posn: 505 TRS/DO

Background includes: Air Battle Manager for AWACS; C2 Planner;OIF, SADO on Combat Ops

- Consolidation of apps would be awesome

- MAAP Toolkit: great for 2,000 sorties, but not fewer
- Web-based functions work best

- From a defensive perspective:

- MIRC chatting collaboration with SADO, SICO, Air Defnse Warning chanes, AAMD & others, folks within the AOC,
- Rotisserie: status of C2 facilities; weapons contrl status; airbase status, C2 status, Weather, space weather,
- Four main screens: 1) COP, 2) threat picture, 3) ADOCS picture, 4) CNN (open source news)

- IOF: spent much time coordinating
- ADOCS, SAA, C2PC: data flows differently between these 3; ADSI was most accurate
- Combine or separate air and ground picture; customizable; same functionality as ADOCS; overlay of ADSI picture; capability for rotisserie (web-based TBMCS data); automated weather feed
- Data back-up is critical
- In-flight status, aircraft status, etc. did not show up at times
    - Used ESTAT a lot
    - Mutli-layer sorting helped a lot
    - Power point print out of ISR assets & collection desk
- IWS chat rooms multiple rooms
- Real-time updates would make ESTAT better
    - Marrying ESTAT and JTIDS would be great

Interview 5:

Current posn: Offensive curriculum development; instructor

Background includes: C-130 pilot; T-37 trainer; misawa AOC, Wing weapons officer; 12 AF; CTAPS, airlift, Combat Plans; Combat Ops, Chief of ATO production; SOUTAF Ops Cell, stood up AOC at Hawaii (PACAF)

- Trying to reduce the number of people for an AOC is not going to work
    - Experts are needed for each function
    - Number of people is tied to the number of functions
    - Skill-set based
- Data walls are useless: CNN and football
    - Big screens are created for the JFACC

- Four screens: 1) CNN or FOX (open source news); 2) COP or tactical air picture (near-real time) and ground force piece; 3) Rotisserie: AOC Director guidance, weather and negative impact on missions, admin; 4) "wild card" screen: ESTAT (Execution STATUS); FSTAT (Forces Status)

ATO Visualization:

- Simplified version of PTT might be a good ATO viz tool
- Grabbing AFMIS tapes and auto forwarding to a display or to Chief of Combat Ops
- "I think ATO should feed AFMIS"
- Unit level to Force level TBMCS; still do paper copies of ATO

Note: level 1, 2, and 3 BDA have changed; Joint Pub governing Combat Assessment and BDA levels

- "ESTAT is an ATO viz tool"
- "ESTAT is filterable"
  - Should be able to view all airspace or a selectable
- "ESTAT is a tabular representation of the ATO
  - 3D graphic with time lapse
  - Most sorties ever seen: 4,700, a dozen at a time, 200 in a shift

Interview 6:

Current posn: DOI; Intel/ISR DO trainer, specialize in targeting.

Background includes: 14N, JEFX, C2 ISRC, ISR Manager, Wing IN, Imagery

Data Wall:

- Useful, except for what might be distracting such as Predator
- Data Walls should be added inside the SCIF
  - COP is critical (red and blue); used as a prompt to call between ops floor & intel
    - Need to integrate the ISR COP; current version presents web-based viewing (ISR Warrior)

Note: AOC in Korea should be considered for data collection.

- On-deck for ATO (flow)
- Weather picture
- In-flight report, BDA, mission reports time sequential list with color codes and pie chart colored as the ATO progresses (entire ATO), related objective, airbase status
- Rotisserie
  - CNN & FOX news
  - Centrally visible

    - IWS chart is used mostly, then MIRC chat; IWS craps out a lot more than MIRC, but, provides more capability than MIRC
- Combine ISR and flying side
- Color code packages and asset types
- Setting defaults is painful
- Combine packages with reporting
- Highlight packages that get re-rolled
- Weather and space effects needs to be there (overlays, transparencies)
- Positive ID (corroborating sources)
- Display of assets available for re-roll (re-task) (more than just acft)

Interview 7:

Current posn: Strategy Course Director

Background includes: Air Battle Manager experience; AWACS, TTP for AF, JEFX TTP (TST); Vicenza, Prince Sultan Air Base (PSAB), Korea, AOC experience, Combat Plans, Combat Ops, Strategy

- JEFX 2000 – Data Wall
- Management of info sharing and data
- Predecessor to TST tools
- Resident ISR expert: Mike England
- Combat Ops: execution visualization tool
- Combat Ops: Ops assessment—a viz tool would be beneficial
- Combat Plans—MAAP Toolkit—resident expert on MAAP Toolkit is “Coach”.
- Air picture
- Info sharing
- General skeds
- ADOCS – SA Tool
- Data management
- Info sharing
- Decision-making support

Pepe’s Suggested Reading List:

    - AOC CONOPS
    - Joint Pubs currently in development
    - AFOTTP 2.3.2
    - Training task list

Interview 8:

Current posn:

Background includes: C-130 pilot; 8 AF; C2WAC, PSAB, Internal Look, OIF, OSW, OCTP, ATO production, Plans Guy

Note: 6-12 May: several personnel from 505 TRS are traveling to Al Udeid to determine where the AOC there is headed.

- Does not use ESTAT, since ESTAT is an execution tool, not a planning tool
- "flow sheet" would help in the ATO production phase
- Wait for MAAP to be completed in MAAP Toolkit and entered into TBMCS; tankers; technical accuracy is critical; tankers are done; send to ATO wings; sent to Ops Floor
- TBMCS doesn't catch a lot of common errors
- Ops floor operators pump it into the system
- MAAP is used to fat-finger it in
- Technical accuracy is checked by tech
- MAAP Chief, ATO production
- ATO vis would be beneficial in Plans
- Flyout tools hasn't seen them
- Rainbow sheet
- Ops guy don't have means of talking to Combat Plans
- ATO Coordinator: supposed to accompany the ATO; LtCol type
- Filters, sorting
- Flyouts not necessary for ATO Plans

Interview 9:

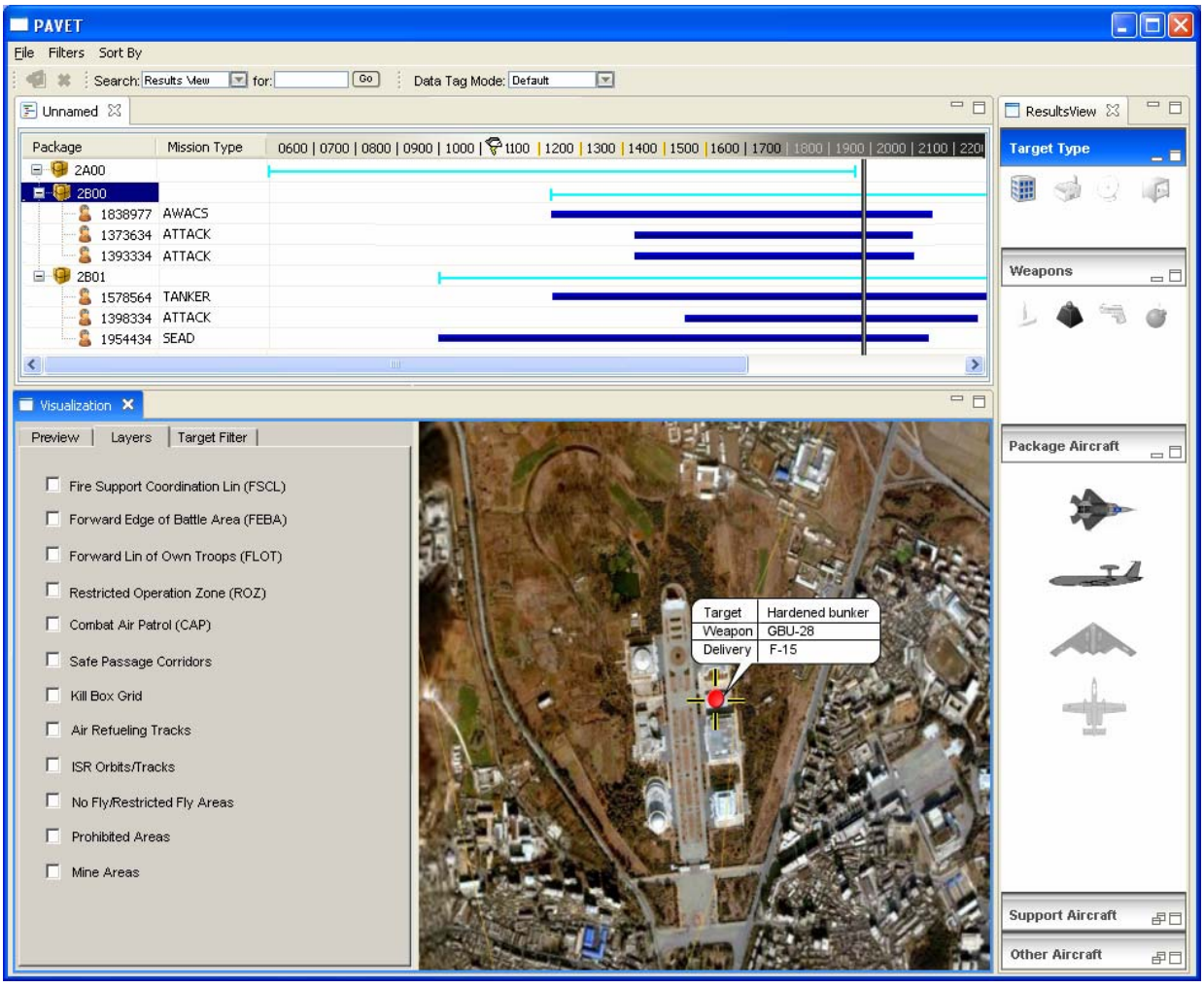
Current posn: CSAR C2 analyst

Background includes: HH-60 pilot; Special Ops Liaison Element (SOLE), test & eval, AOC Duty Officer,

- "ESTAT is not necessarily a visualization tool"
- Visualization tool should be a template, customizable
- Current ADOCS display is good for Rescue

- Data Wall: should include display of routes and rescue choppers as well as CSAR

Appendix C. Visualization Prototypes



Overview - This shows the view of a single target, or DMPI. Holding the cursor over the target will reveal information on the target, including but not limited to: BE number, target type, weapon selected, and delivery method. The focus of this view is focused on a single target and purposefully leads to slides that focus on the big picture and how the user arrives at assigning weapons and packages (a package being a group of aircraft that work in tight cooperation to achieve a focused goal) to a specific target.

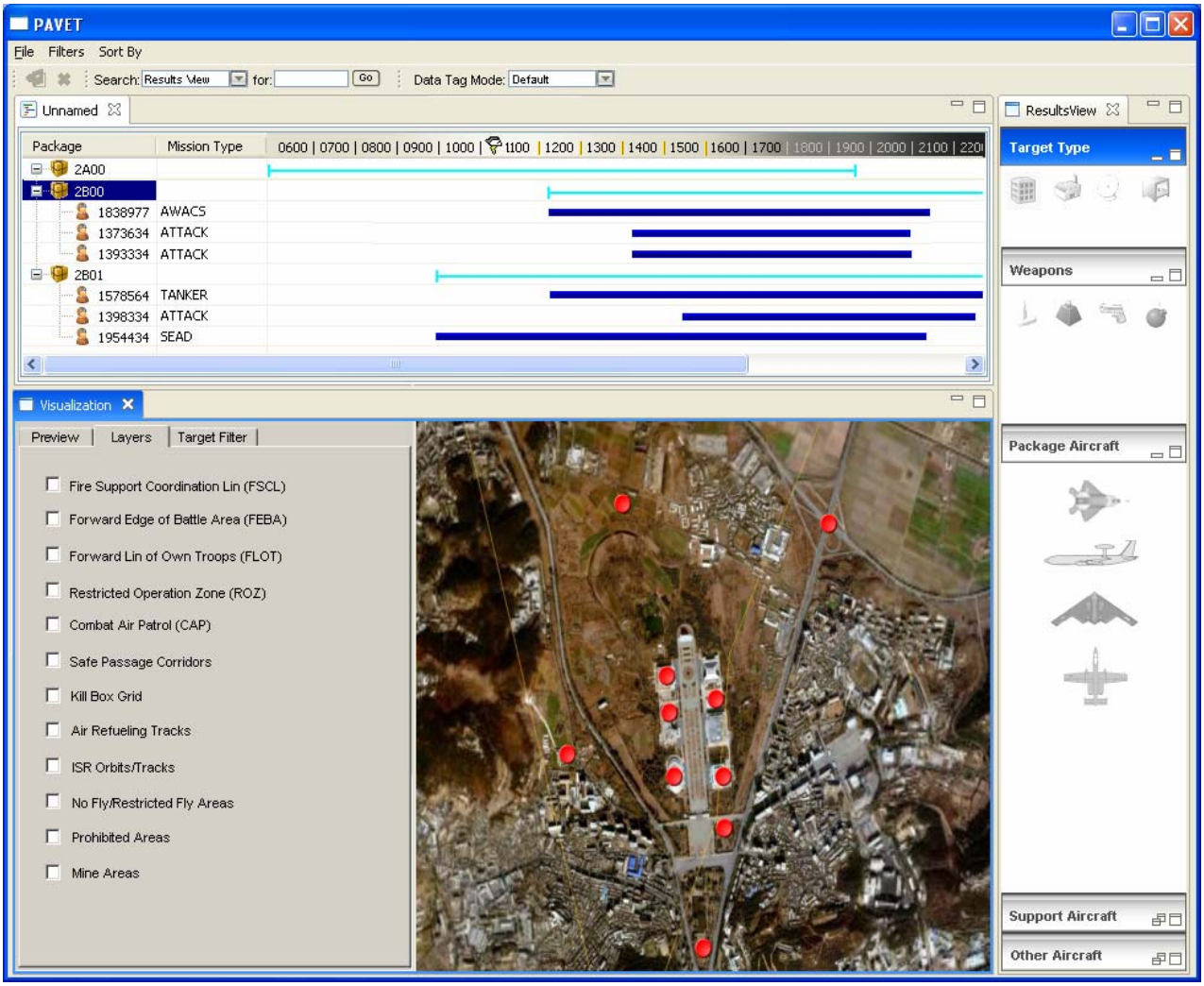
Functionality – Timeline View on the top of the screen shows the user the overall timeline for planning purposes including available aircraft packages, weather information and sunrise/sunset and moonrise/moonset information. Vertical timeline represents the point in time when this target is being engaged.

Assignment Windows – Windows on the right side give user the ability to drag-and-drop icons onto target. If "target type" is not available from BE data or if the user wants to change the target type they can drag-and-drop a new designation onto the target. User

can reference JMEMS or drag target onto JMEMS interface for recommended weapons. Weapons can be dropped onto targets on the map. Weapons are linked with aircraft that have the capability to deliver them. After a weapon is selected only appropriate aircraft will be highlighted, the rest will be grayed out. Selected target is "linked" visually with Package in the Timeline view.

Tabbed Windows – These tabs give the user a great deal of flexibility when viewing the map, when selecting data to be represented on the map, when searching for target information and when operating in "simulation mode". Options can be selected at any time by the planner, providing a wealth of easily understood information.

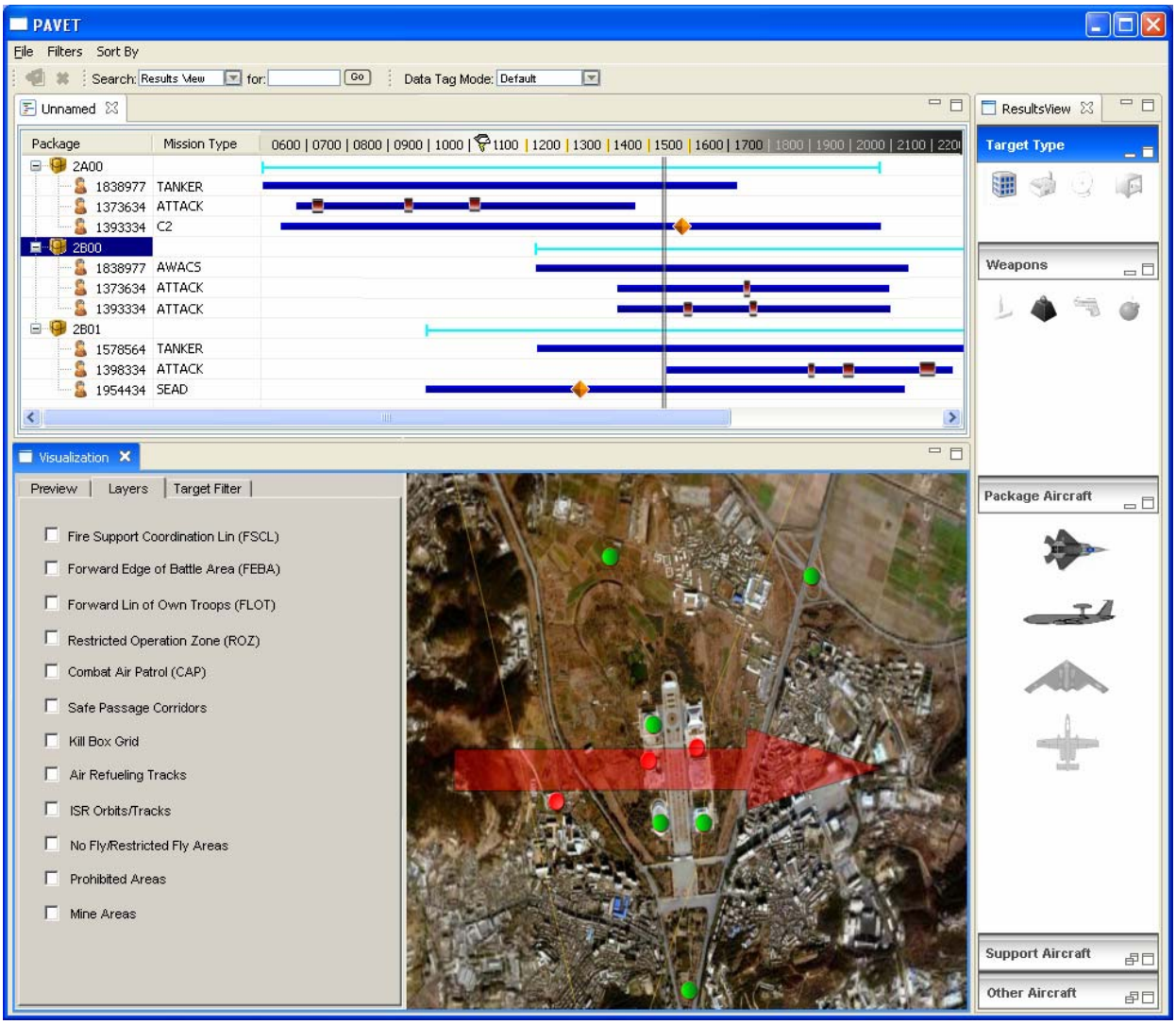
Transition to Slide 2 – It's critical to acknowledge that a single target doesn't exist in isolation. Any target is part of a much larger plan and needs to be considered in that context. In context, this target is one target of four assigned to one attack aircraft, the attack aircraft is part of a package including support aircraft of varying types, that package has to work in concert with other packages which, in turn, are coordinated with still more packages.



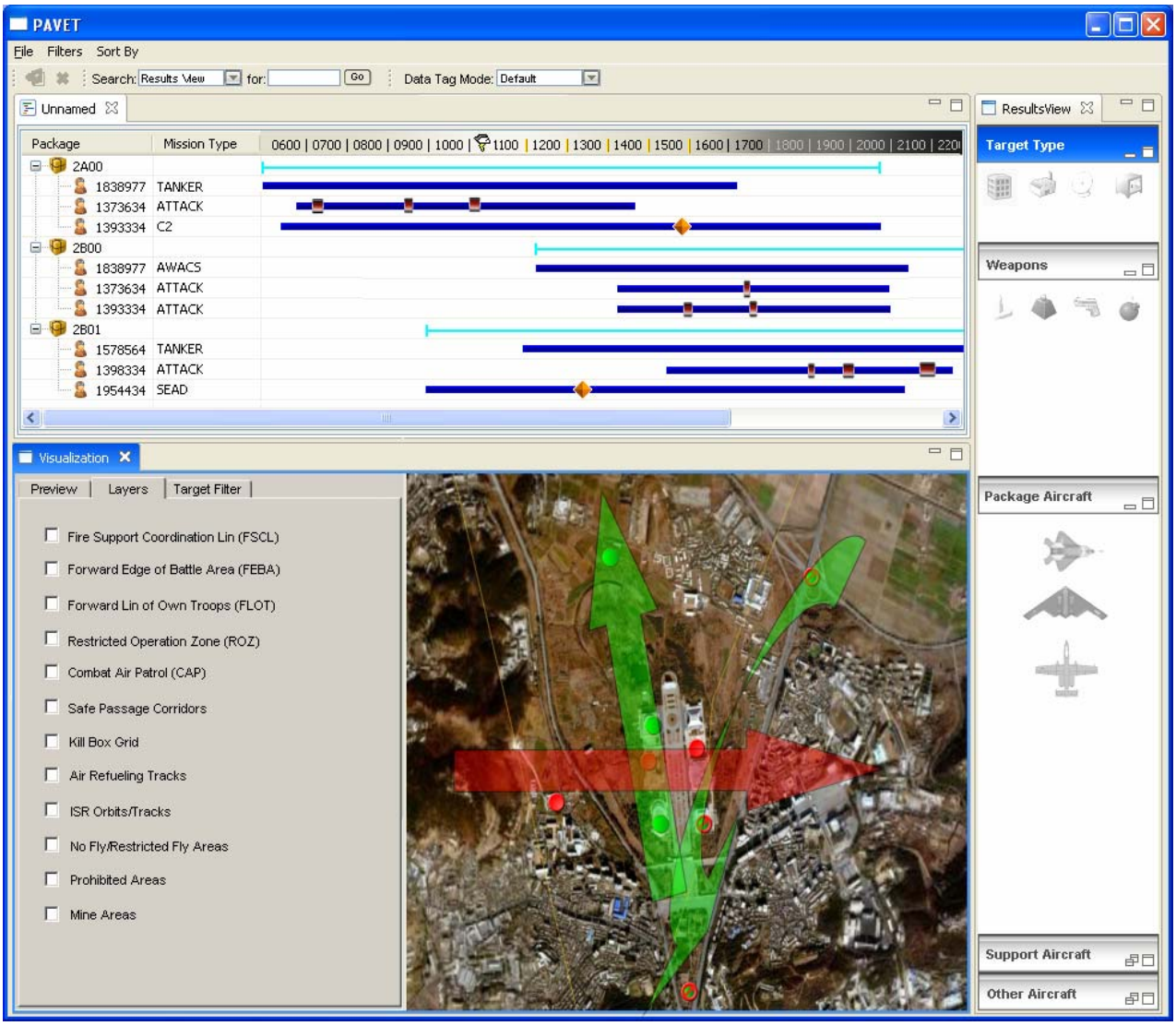
This screen is much earlier in the planning process. The planner sees all targets in the vicinity (as opposed to a single target) and needs to assign weapons and aircraft packages to each. The planner will need to take into account a multitude of factors, some represented in the "Layers" tab to the left of the map, but also including available armaments, weather, time of day, defenses and available packages.

The Timeline view, at this point, represents what packages are available at what times. The planner, factoring in all pertinent information will select the appropriate packages and assign them to a group of targets. Then this "group" will be part of the overall ATO.

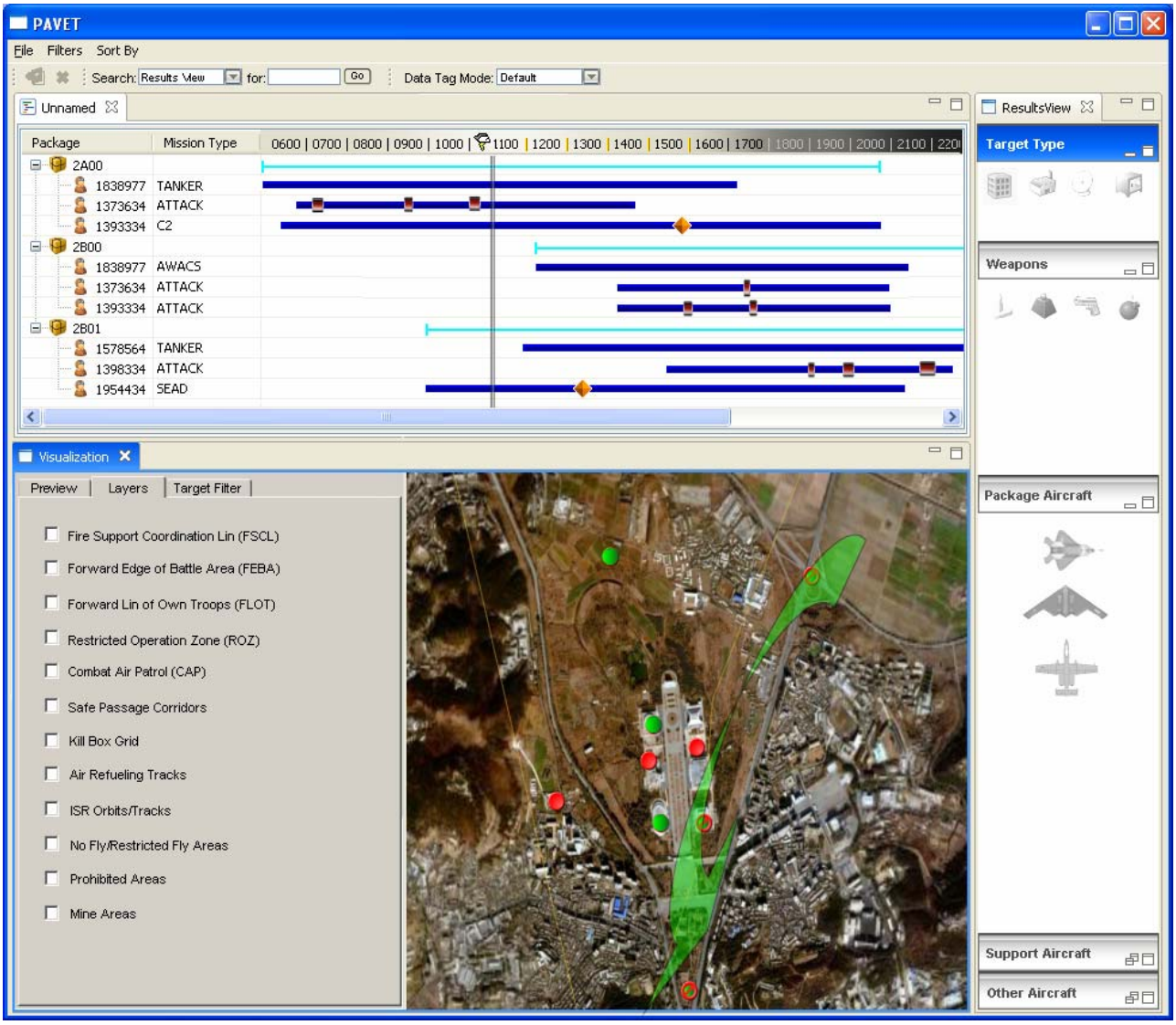
The following screenshots show how this part of the ATO will play out based on the planners coordination of resources.



This screenshot represents the beginning of planning for a specific package, 2B00. The timeline is set to represent the departure of the packages attack aircraft. At this point the user has some overall idea of what types of targets he needs to attack, what aircraft are available, what weaponry is available an any other constraints on his work. With all input considered he knows that this particular package "matched up" with this set of targets. So he assigns the package and provides ingress/egress directions, approximate times and moves to the next set of targets.

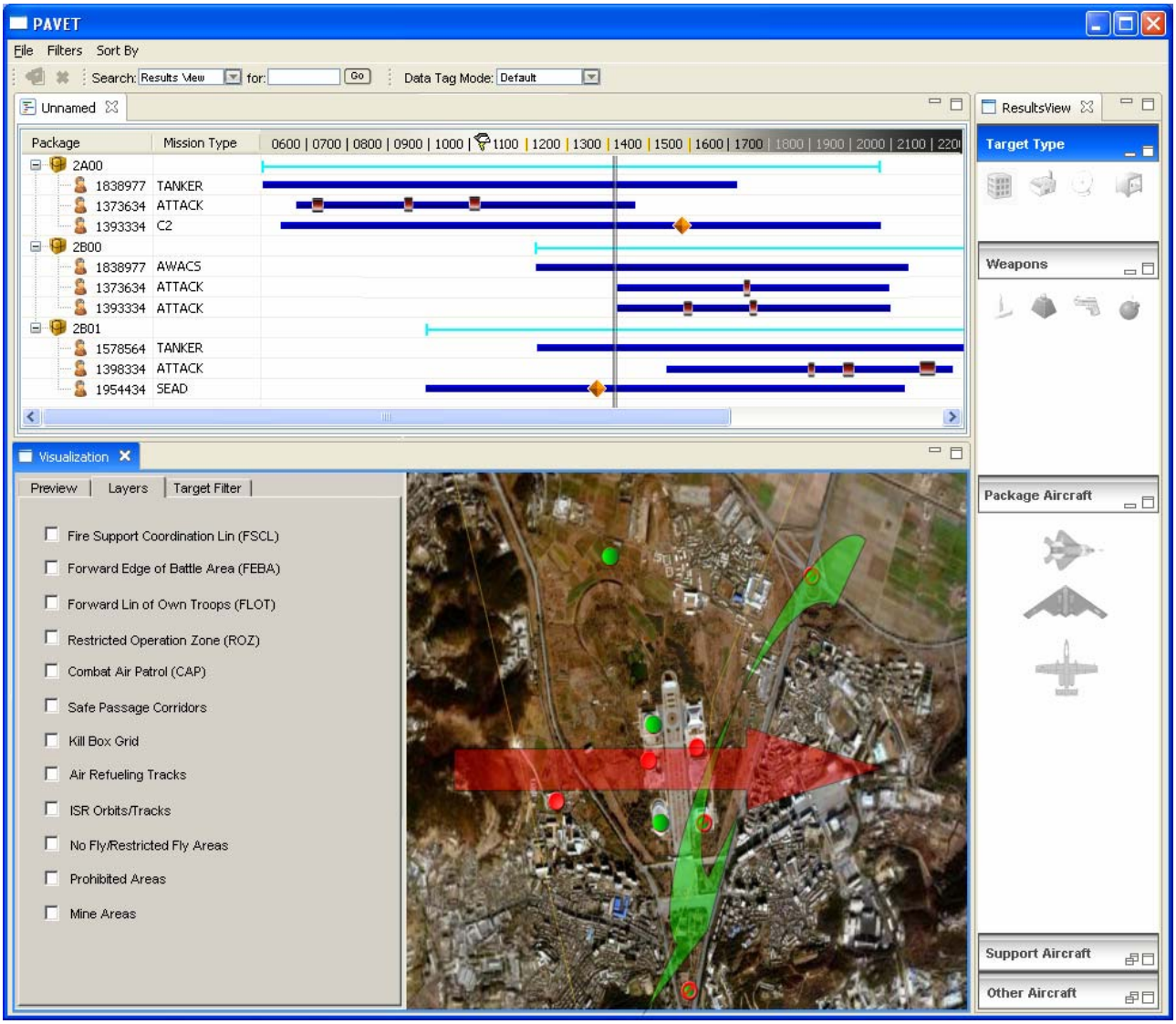


This shows the final plan for this set of targets. Three packages will attack the targets. Selecting an arrow will provide the details associated with each package and indicate which targets are being attacked, approximate times of attack, aircraft in the package, and armaments being used.

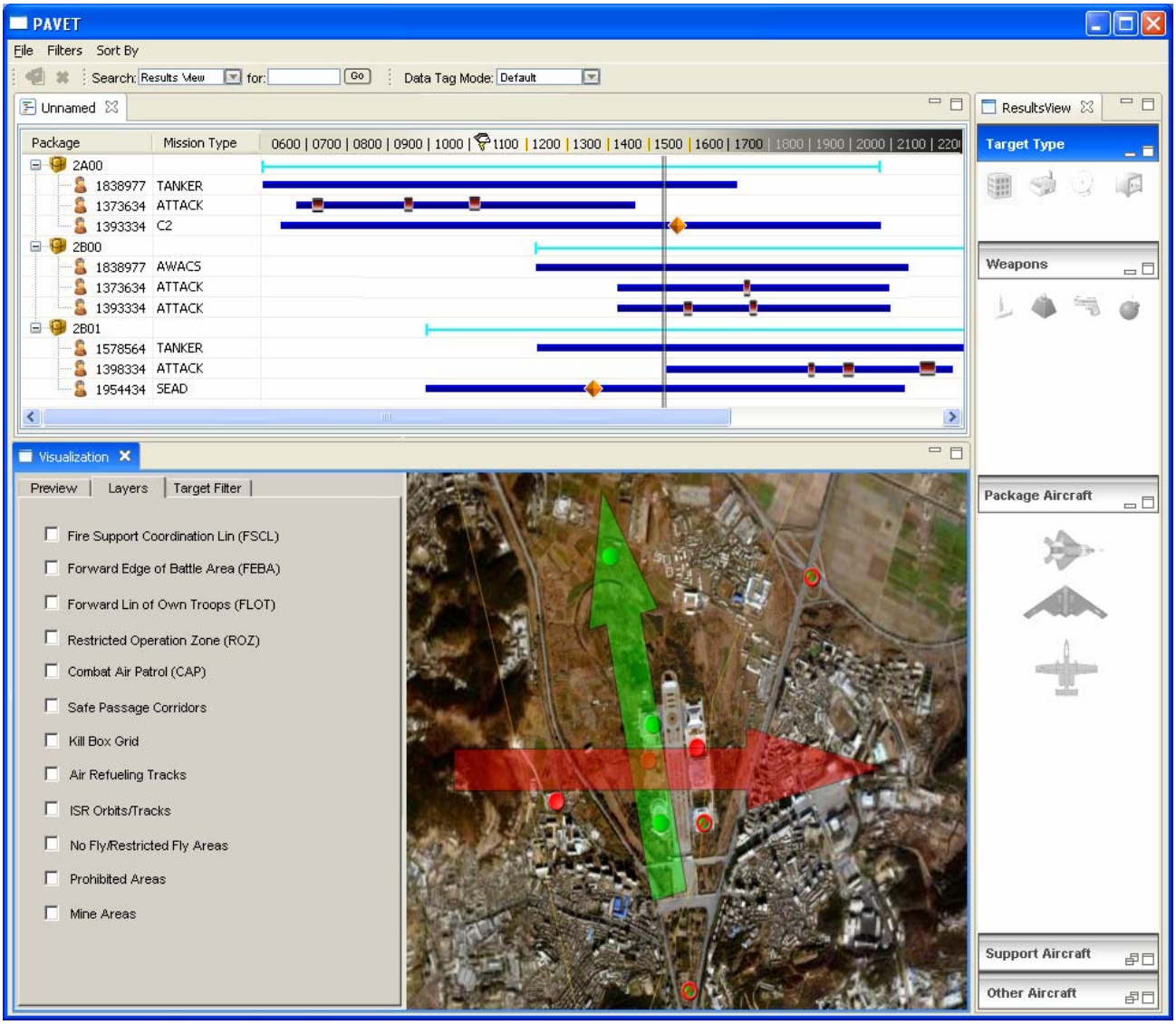


This screenshot, and the next two, act as a sort of simulation of the ATO Plan in action. The time bar in the Timeline View will be moved across the screen and aircraft packages will attack the targets on the map. As the time bar follows the map, the arrows in the map view appear and disappear as the attack aircrafts are scheduled to hit their targets. The arrows are keyed to attack aircraft because other aircraft may be in support of other packages as well. This clarifies for the user when attack missions are occurring and will also inform, in a generic manner via the map – a specific manner via the Timeline, that other support aircraft in the area. With the entire ATO planned we know there are 3 "attacks" that will handle the 9 targets on the map.

The first attack, Package 2A00, follows the path of the arrow and strikes the 3 green targets with the universal red "no" symbol superimposed on them. In subsequent screens the same coding will be used to indicate targets that should have already been attacked. The red dots indicate the targets for our selected package (note: package 2B00 should be highlighted in the Timeline View). Green dots indicate targets for non-selected packages. Icons on particular aircraft's timeline indicate time of attack.

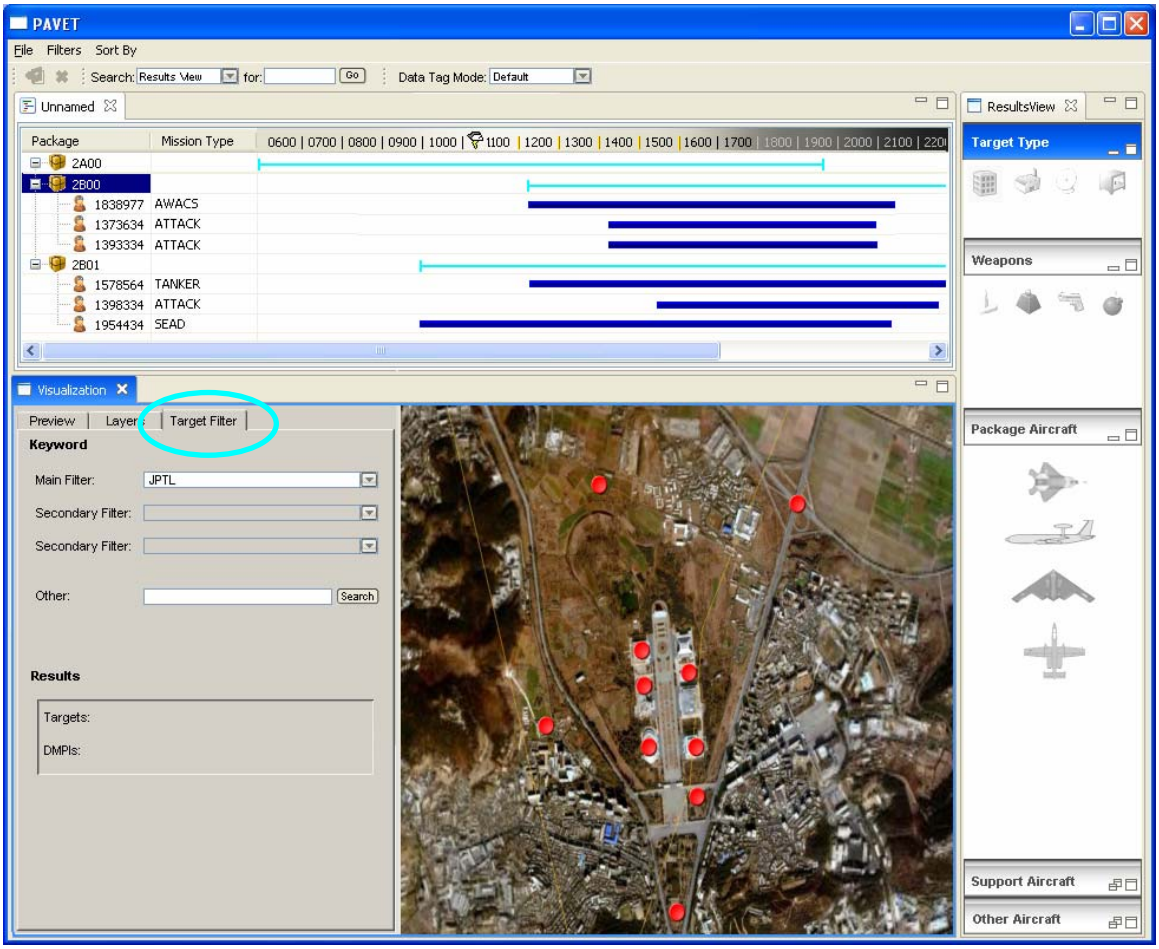


At this point, we can see that the first attack package is still in the air after attacking the targets and the second attack is yet to occur. The presence of the arrows on the screen indicates that the aircraft are in the air, by looking at the timeline view we see the status of the attacks.

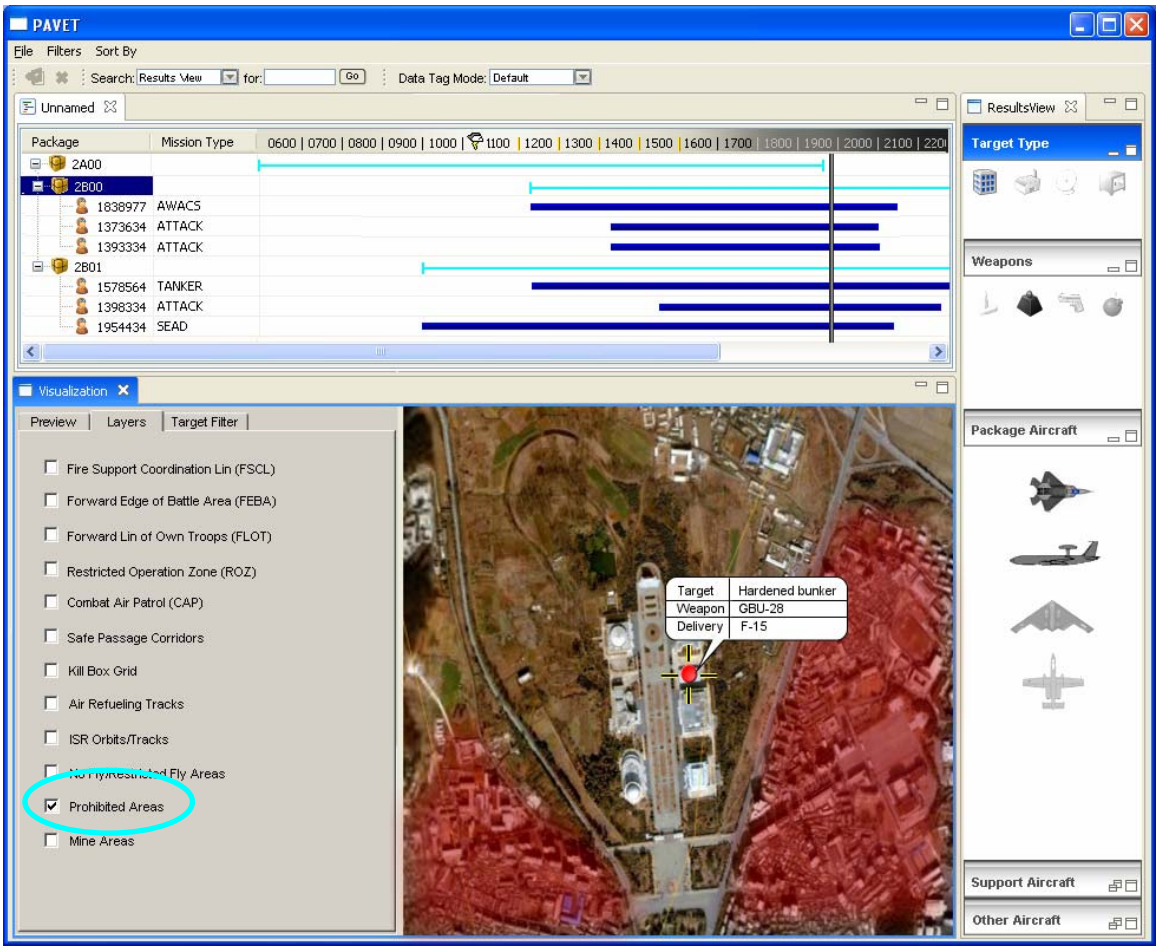


The final slide of the “simulation”, similarly to the second, shows the status of the aircraft and targets at a glance. We can immediately see that the first attack has occurred and that the attack aircraft are out of the area, the second attack is about to occur and the final attack is now in the air and approaching the target.

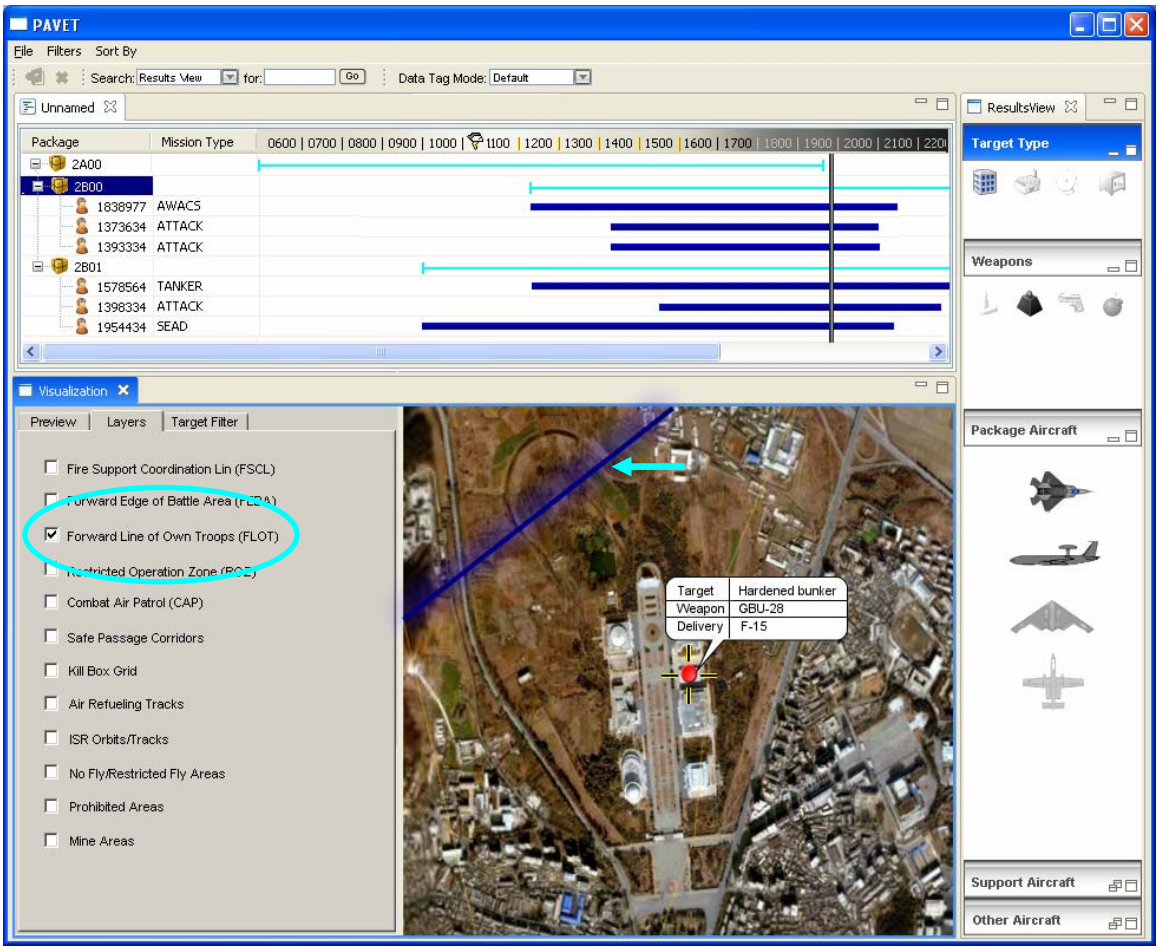
The following are **functionality** concepts showing various tools and features could be included to aid the user in planning an ATO. These concepts are presented in no particular order, rather just as a set of ideas that can be incorporated within the overall UI design.



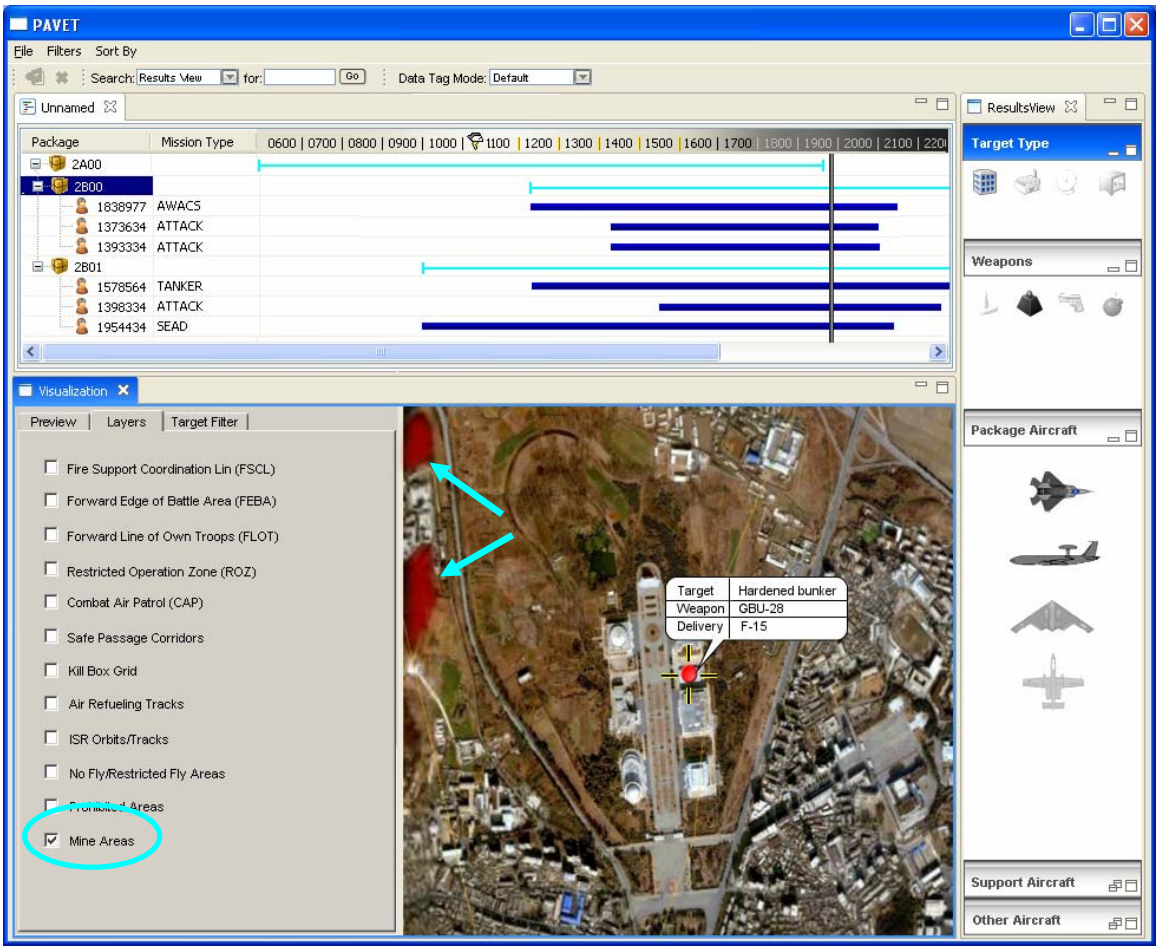
Target Filter Tab. Target Filter – Allows the user to filter what targets are shown in the visible map area.



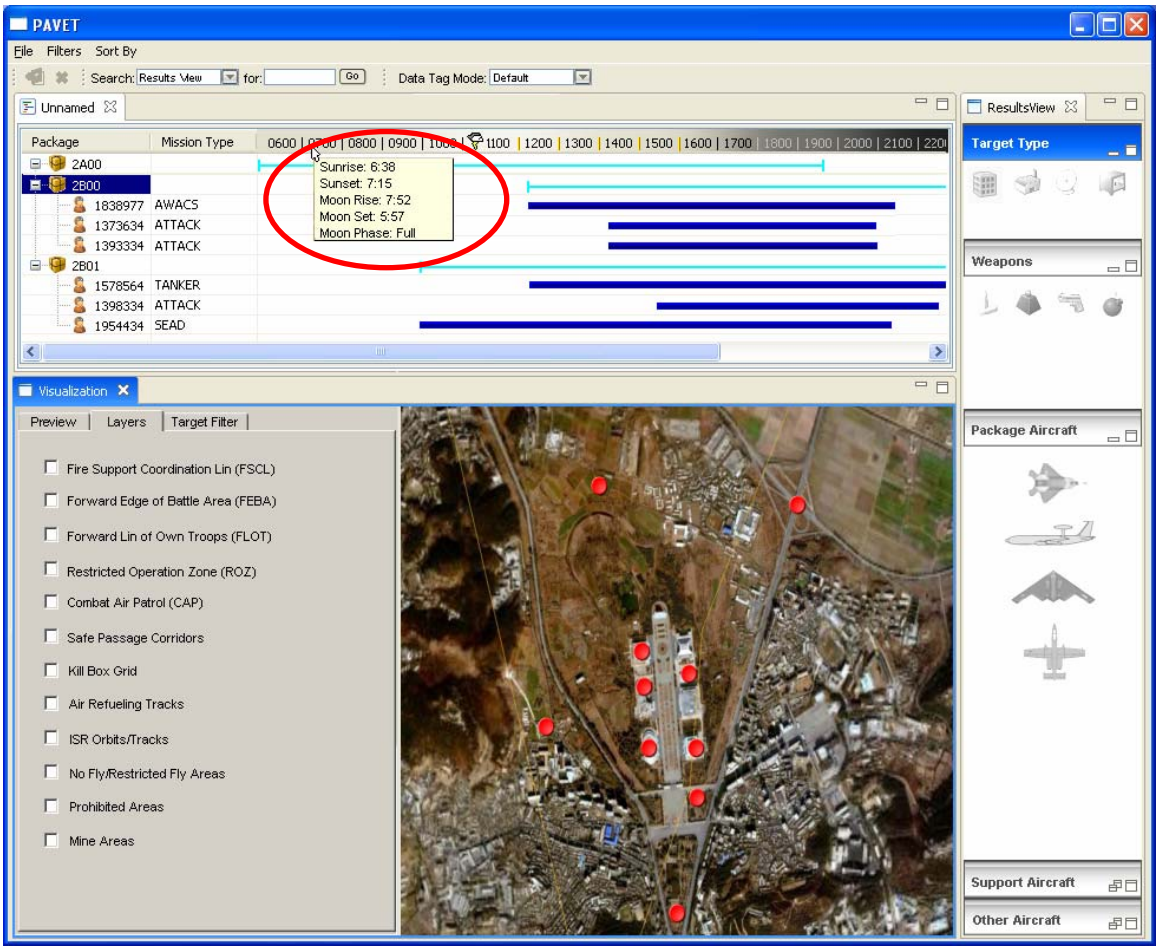
Prohibited Areas Layer



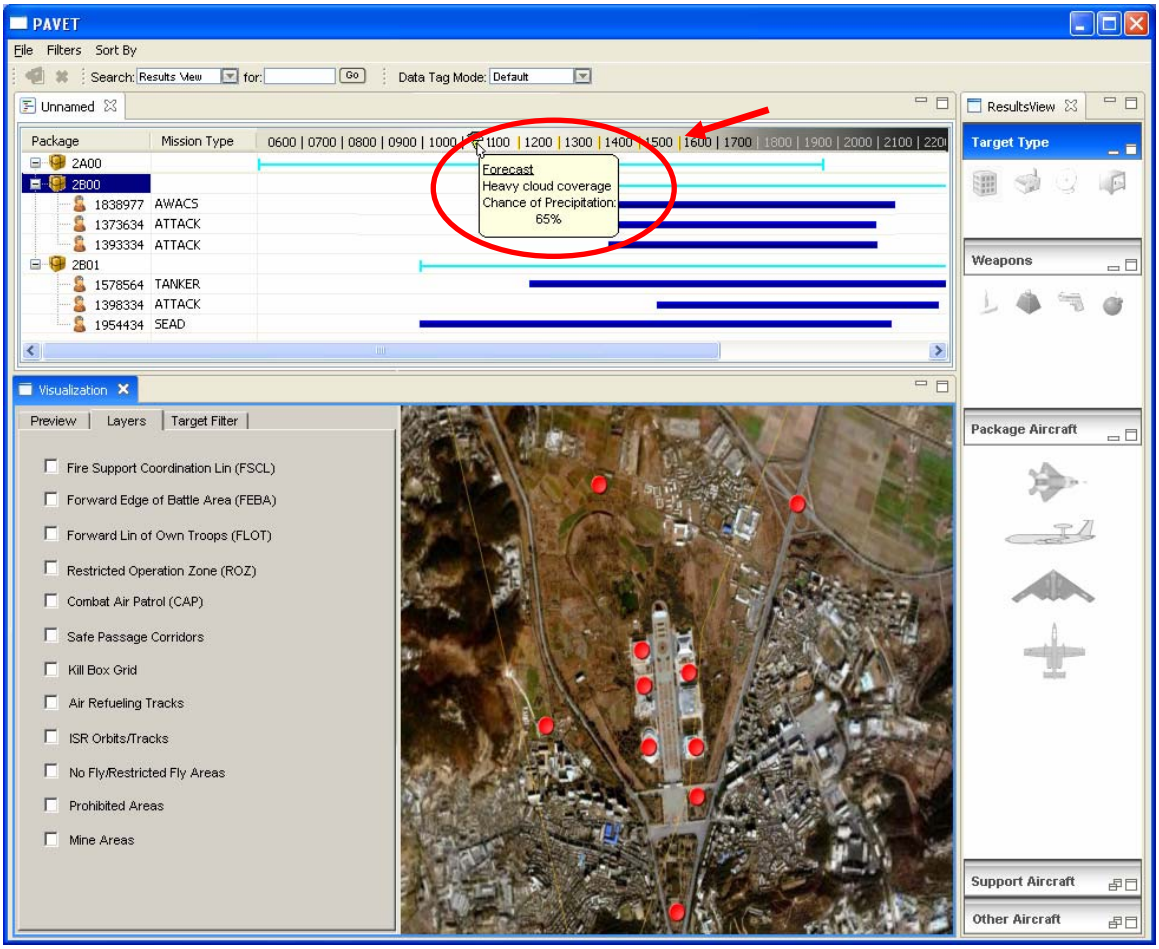
Forward Line of Own Troops


PAVET
File Filters Sort By
Search: Results View for: Go Data Tag Mode: Default
Unnamed
Package Mission Type 0600 | 0700 | 0800 | 0900 | 1000 | 1100 | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 | 220
2A00
2B00
1838977 AWACS
1373634 ATTACK
1393334 ATTACK
2B01
1578564 TANKER
1398334 ATTACK
1954434 SEAD
Visualization
Preview Layers Target Filter
Fire Support Coordination Lin (FSCL)
Forward Edge of Battle Area (FEBA)
Forward Line of Own Troops (FLOT)
Restricted Operation Zone (ROZ)
Combat Air Patrol (CAP)
Safe Passage Corridors
Kill Box Grid
Air Refueling Tracks
ISR Orbits/Tracks
No Fly/Restricted Fly Areas
Mine Areas
Target Hardened bunker
Weapon GBU-28
Delivery F-15
ResultsView
Target Type
Weapons
Package Aircraft
Support Aircraft
Other Aircraft

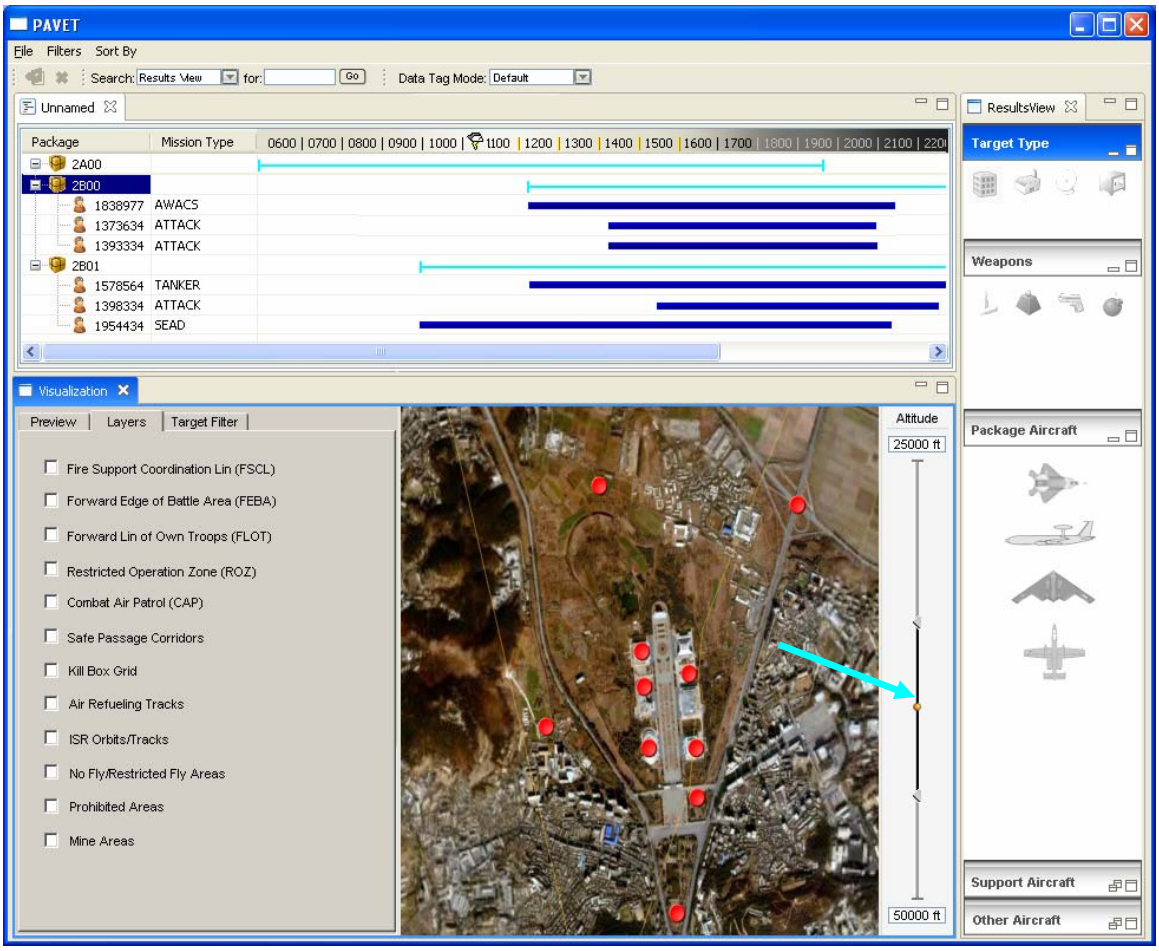
Mine Areas



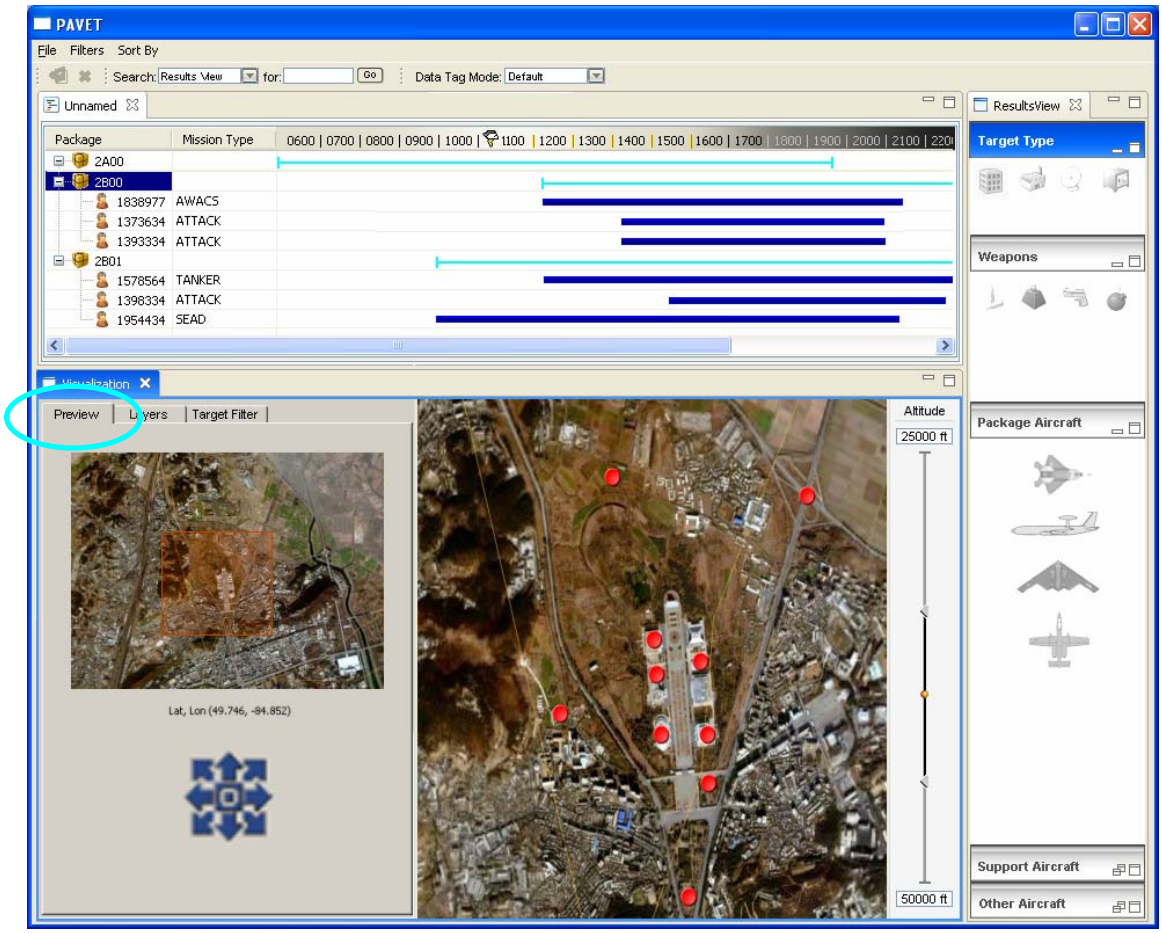
Sunset/sunrise scroll



Weather scroll – note the yellow bars indicating length of weather warning.



Vertical sorter – The map allows the user to switch from a bird's eye view to a horizontal view.



Preview Tab. Preview Tab – Allows the user to move around in the map area, zoom-in, zoom-out, etc.

Acronym List

AADC	Area Air Defense Commander
ABP	Air Battle Plan
ACM	Air Control Measures
ACP	Airborne Command Post
ADOCS	Automated Deep Operations Coordination System
ADP	Air Defense Plan
ADSI	Air Defense Systems Integrator
AFB	Air Force Base
AFFOR	Air Force Forces
AFFORTTP	Air Force Forces Tactics Techniques and Procedures
AFMIS	Air Force Management Information System
AOC	Air & Space Operations Center

AOD	Air Operations Directive
AOR	Area Of Responsibility
ASOC	Air Support Operations Center
ATDM	Advanced Team Decision Making
ATO	Air Tasking Order
AWACS	Airborne Warning And Control System
BDA	Battle Damage Assessment
BDC	Battle Damage Control
BE	Basic Encyclopedia
C/JFACC	Combined/Joint Forces Air Component Command
C/JFC’s	Combined/Joint Force Commander's
C2	Command and Control
C2PC	Command and Control Personal Computer
C2WAC	Command & Control Warrior Advanced Course
CAP	Combat Air Patrol
CCD	Camouflage, Concealment, & Deception
CCO	Chief of Combat Operations
CDM	Critical Decision Method
CENTAF	U.S. Central Command Air Forces
CNN	Cable News Network
COD	Combat Operations Division
COMAFFOR	Commander Air Force Forces
COMINT	Communications Intelligence
COP	Common Operational Picture
CPD	Combat Plans Division
CSAR	Combat Search And Rescue
CSSE	Combat Service Support Element
CTA	Cognitive Task Analysis
DCA	Defensive Counter Air
DLARS	Data Link Automated Reporting System
DMPI	Desired Mean Point of Impact
DOI	Defensive Operations Instructor
DT/TST	Dynamic Target/Time Sensitive Target
ELINT	Electronic Intelligence
ESTAT	European Surface-to-Air Tactics Analysis Team
EW	Electronic Warfare
ICC	Intelligence Coordination Center
ICO	Interface Control Officer
ID	Identification
IMINT	Imagery Intelligence
IRs	Intelligence Requirements
IWS	Integrated Warfare Systems
IWS	Integrated Warfare Systems
JAOP	Joint Air Operations Plan
JCEOI	Joint Communications-Electronics Operations Instructions
JFOR	Joint Forces

JIPTL	Joint Integrated Prioritized Target List
JMEMS	Joint Munitions Effectiveness Manuals
JRFL	Joint Restricted Frequency List
JSSE	Joint Service Support Element
JTC	Joint Theater Commander
JTL	Joint Task List
LINK	Logistics Information Network
MAAP	Master Air Attack Plan
MASINT	Measurement and Signatures Intelligence
MEC	Mission Essential Competencies
METOC	Meteorological and Oceanographic
MIRC	Military Intelligence Reserve Command
NATO	North Atlantic Treaty Organization
NCOIC	Non-Commissioned Officer In Charge
NSL	No Strike List
OCTP	Organizational Command Training Program
OIF	Operation Iraqi Freedom
OPLAN	Operational/Operations Plan
OPTASK	Operational Tasking
OSW	Operation Southern Watch
OTCP	Officer Training Command Pensacola
PACAF	Pacific Command Air Forces
PED	Processing, Exploitation and Dissemination
PSAB	Prince Sultan Air Base
PTT	Part Task Trainer
RAP	Recognized Air Picture
ROE	Rules Of Engagement
ROW	Rest of World
RPD	Recognition-Primed Decision Model
RSTA	Reconnaissance, Surveillance, and Target Acquisition
RTL	Restricted Target List
SA	Situation Awareness
SAA	Situation Awareness and Assessment
SADO	Senior Air Defense Officer
SCIF	Sensitive Compartmented Information Facility
SEAD	Suppression of Enemy Air Defense
SICO	Sector [or Senior] Interface Control Officer
SITREP	Situation Report
SME	Subject-Matter Expert
SODO	Senior Operations Duty Officer
SOLE	Special Operations Liaison Element
SOUTHAF	Southern Command Air Forces
SPINS	Special Instructions
SRA	SRA International, Inc.
STO	Special Technical Operations
TACOPDAT	Tactical Operation Data

TACS	Tactical Air Control System
TBMCS	Theater Battle Management Core Systems
TBONE	Theater Battle Operations Net-Centric Environment
TDL	Tactical Data Link
TET	Targeting Effects Team
TKA	Team Knowledge Audit
TMD	Theater Missile Defense
TNL	Target Nomination List
TOT	Time on Target
TST	Time-Sensitive Target
TTP	Tactics, Techniques & Procedures
WAW	Warfighter Analysis WorkshopAFB Air Force Base